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ABSTRACT

Based on a review of literature on educational change, this study explored the fundamental dynamics of stability and change in public school systems. Five major factors were identified that affect and interact with innovation. These factors include leadership effectiveness, external funds, external linkage, conflict, and support for innovation. Support for innovation is a function of the relationship between the level of innovation and leader, professional, and community norms. A computer model was constructed that expressed mathematically the relationships among these factors that account for the change behavior of school systems over time. Computer runs demonstrated the ability of the model to reproduce the ebb and flow of innovation in school districts over time, both where stability of community norms is assumed and where the community is seen in a state of transition. Findings indicated that a small number of fundamental structurally interconnected elements account for the basic stability of schools in the face of efforts to innovate. Also, incremental approaches to innovation seem to produce long-term effects superior to effects of dramatic attempts to bring about quick change. Finally, policies promoting networking among school people produce more positive impact on innovation than policies based on funding alone. (Author/JM)

TOWARD A STRUCTURAL THEORY OF INNOVATION IN PUBLIC SCHOOLS

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ABSTRACT

The past twenty years have seen substantial commitments of money and personnel to changing American public schools. Major innovations supported by public agencies and private foundations, as well as legislative and judicial bodies, include team teaching, individualized instruction, curricular reform in science and mathematics, racial desegregation, and educational mainstreaming of children with special needs.

The results of these reform efforts suggest that schools exhibit strong tendencies toward stability in the long-term. The purpose of the reported research was to understand the fundamental dynamics of stability and change in public school systems.

Based upon a review of the literature on educational change, five major factors were identified which impact upon and interact with innovation. These factors include leadership effectiveness, external funds, external linkage, conflict and support for innovation. Support for innovation is a function of the relationship between the level of innovation and leader, professional and community norms.

A computer model was constructed which expressed mathematically the relationships among these factors which account for the change behavior of school systems over time. Computer runs demonstrated the ability of the model to reproduce the ebb and flow of innovation in school districts over time, both where stability of community norms is assumed and where the community is seen in a state of transition.

The model was used to evaluate the effects of several kinds of policies designed to effect innovation and to understand the system dynamics which produce these effects.

Several conclusions emerged from the study:

1. There seem to be a small number of fundamental elements which are structurally interconnected.

ABSTRACT (continued)

around public schools which account for the basic stability of schools in the face of efforts to innovate;

2. Incremental approaches to innovation seem to produce superior long-term effects in comparison to dramatic attempts to bring about change quickly;

3. Policies which seek to promote networking among school people seem to produce more positive impact upon innovation than policies based upon funding, alone.

The study is important both methodologically and substantively. Methodologically, it illustrates a perspective which represents a significant alternative to traditional regression techniques for hypothesis testing and describes the application of an important management science tool for theory development and policy analysis. Substantively, the results lend support to the current policy thrust of the National Institute of Education in support of networking. They also highlight the counterintuitive effects of overzealous efforts toward reform in producing system instability, high levels of conflict, and little long-term innovation. Finally, this approach to analysis provides understandings of the dynamics of systemic interaction which produce these counterintuitive effects.

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OF INNOVATION IN PUBLIC SCHOOLS

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INTRODUCTION

Despite substantial and well-publicized efforts to effect change in the public schools, the schools have been found by observers to be not very different over long periods of time. Based upon an empirical study of a large number of schools which were reputed to be especially innovative, two researchers suggested recently that claims of innovation were typically exaggerated.

> A very subjective, but nonetheless general impression of those who gathered and those who studied the data was that some of the highly recommended and publicized innovations of the past decade or so were dimly conceived and at best, partially implemented in the schools claiming them. The novel features seemed to be blunted in the effort to twist the innovation into familiar conceptual frames or established patterns of schooling. For example team teaching, more often than not was some pattern of departmentalization and nongrading looked to be a form of homogeneous grouping. Similarly the new content of curriculum projects tended to be conveyed with the baggage of traditional technology. (Goodlad and Klein, 1974, p. 72)

The dynamic described by Goodlad and Klein is essentially that captured by the concept of mutual adaptation

(Greenwood, et.al., 1975) and reemphasizes the significance in school districts of existing regularities (Sarason, 1971). It is important to recognize that, for every school, an innovation represents a departure, to one extent or another, from current norms. These current norms represent points of departure against which to gauge the extent of innovation; they also constitute sources of pressure from which forces emanate seeking a return to more traditional practices. The further and faster a school moves away from existing norms, the stronger and more persistent the counterforces of reaction, at least within some reasonable time frame.

It was the purpose of the study herein reported to describe the fundamental forces of change and stability in public school systems, to construct a working model of these forces, and to assess dynamically the impact of historic policies intended to bring about change in the public schools.

THE PROBLEM

There are no firm data which describe over time the innovative behavior of public school systems. Statistical reports are available which describe the growth in this century of public schools in terms of numbers of students, numbers of teachers, revenues, expenditures, etc. There are available, however, no trend data which depict the institutionalization and de-institutionalization of significant innovations such as individualization of instruction, team teaching, and major shifts in the content and methodology of instruction. It is known that reports on the implementation and evaluation of innovations are significantly error-prone (Goodlad and Klein, 1974; Charters and Jones, 1975) and that data on the diffusion of innovations in public schools are impressionistic at best. Data on implementation are poor; those on discontinuation are almost non-existent.

As a result of the data deficiencies with respect to the implementation and discontinuation of educational innovations, not only can no clear explanations be made, but no firm interpretations can be put forth about the nature of the problem, itself. For example, Goodlad and Klein suggest a historical reference mode of behavior which depicts schools as fundamentally non-innovative (Fig. 1).

> One conclusion stands out clearly: Many of the changes we have believed to be taking

place in schooling have not been getting into the classroom; changes widely recommended for the schools over the past 15 years were blunted on the classroom door. (Emphasis added) (Goodlad and Klein, 1974)

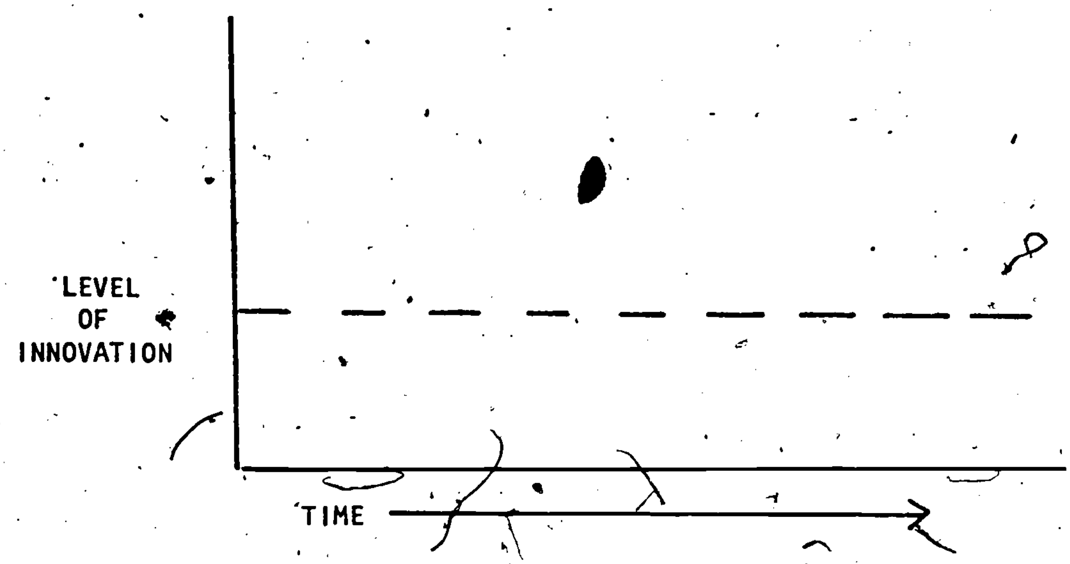

Fig. 1. Reference Behavior Mode: Schools as Non-Innovative Over Time.

Case studies (Weiser, 1976; Wolcott, 1977), as well as common experiences, suggest, however, that the depiction of public schools as statically non-innovative may represent neither a valid nor a useful problem perspective. Over the past two decades, a great deal of money, from Federal, state, local and foundation sources, has been put into changing schools. Large numbers of committed and talented individuals have devoted time and energy to the business of school reform. Whole agencies and educational collaboratives of one kind and another have worked toward the invention, development, diffusion, adoption, implementation, evaluation and institutionalization of educational innovations. Much of the educational leadership of many decades, from Dewey and Counts to Trump and Goodlad, has been harnessed in the service of school reform. It is inconceivable that these efforts have been without even temporary effect.

The problem upon which the reported research focused was presented from a perspective substantially different from that represented by the statically non-innovative

perspective. Public schools from the dynamic perspective are perceived as being both changing and unchanging, as implementing and discontinuing innovative practices over time.

According to this perspective, innovations and discontinuations are occurring in public schools simultaneously at all times. Innovations and discontinuations occur in relation to the prevailing norms of leaders, professional staff, and citizens. During some periods within, let us say, a fifty year time frame, one or the other, innovation or discontinuation, will be in the ascendance. At each point in time, both behaviors will be occurring. Regardless of which is then dominant, there will always be forces operating to return the educational program to a state more consistent with prevailing norms, and the system will tend to oscillate with respect to innovation around these norms. Leader, professional, and community norms are seen to be affected by each other and by innovations, but only slowly over time. This dynamic perspective of change in public schools (Fig. 2) stands in contrast to the statically non-innovative perspective.

Both perspectives account for the data which suggest that schools don't change much over long periods of time. The two perspectives are different, though, with respect to their perceptions of the behavioral paths and of the dynamics which give rise to system behavior.

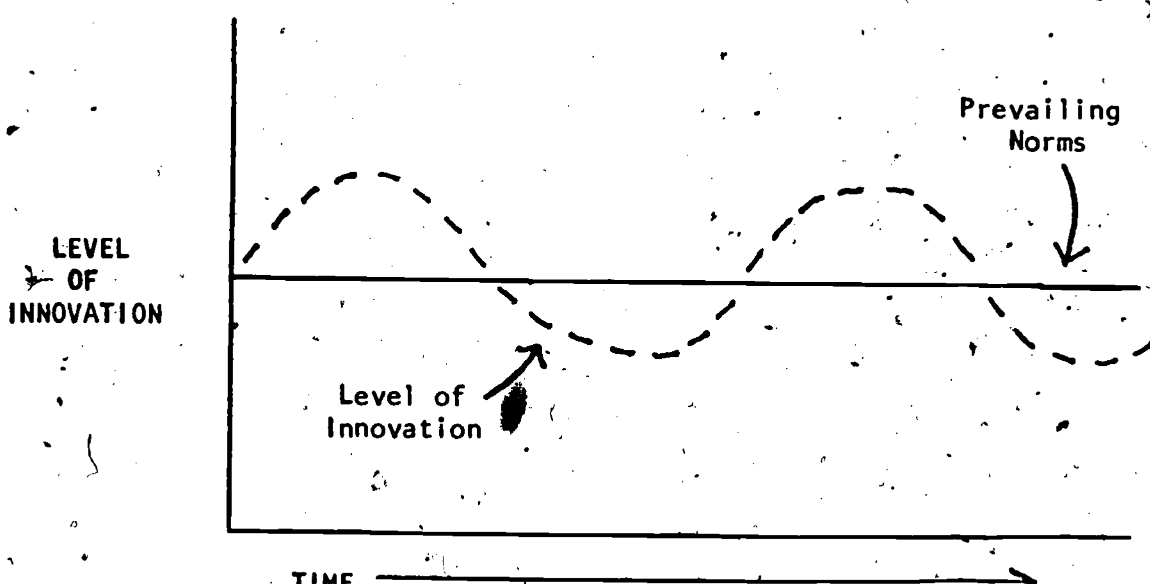

Fig. 2. Reference Behavior Mode: Dynamic Perspective of Change in Public Schools.

Given the assumption of the dynamic perspective, the first research task became that of explaining the reference behavior associated with that assumption. This necessitated the depiction of a structure which was logically defensible to persons familiar with public schools and with innovative activity in public schools and which, when represented mathematically in a computer simulation model, could actually reproduce the reference behavior mode (Fig. 2). It also seemed important that the model be capable of reproducing the known behavior of school systems under conditions of transitional community norms and provide utility in the evaluation of relevant policy options.

There have been many cases in this country of communities changing demographic characteristics to a significant degree over some period of time. What typically occurs in such transitional communities is that educational norms tend to shift along with the demographics and, with empirically inherent delays, pressures are brought to bear upon the school system to modify the educational program in the direction of the emergent norms (Iannaccone & Lutz, 1970, pp. 69-233). It seemed that any test of the validity of the theoretical structure represented by the model should include an evaluation of the model's ability to reproduce known system behavior in response to changing community norms.

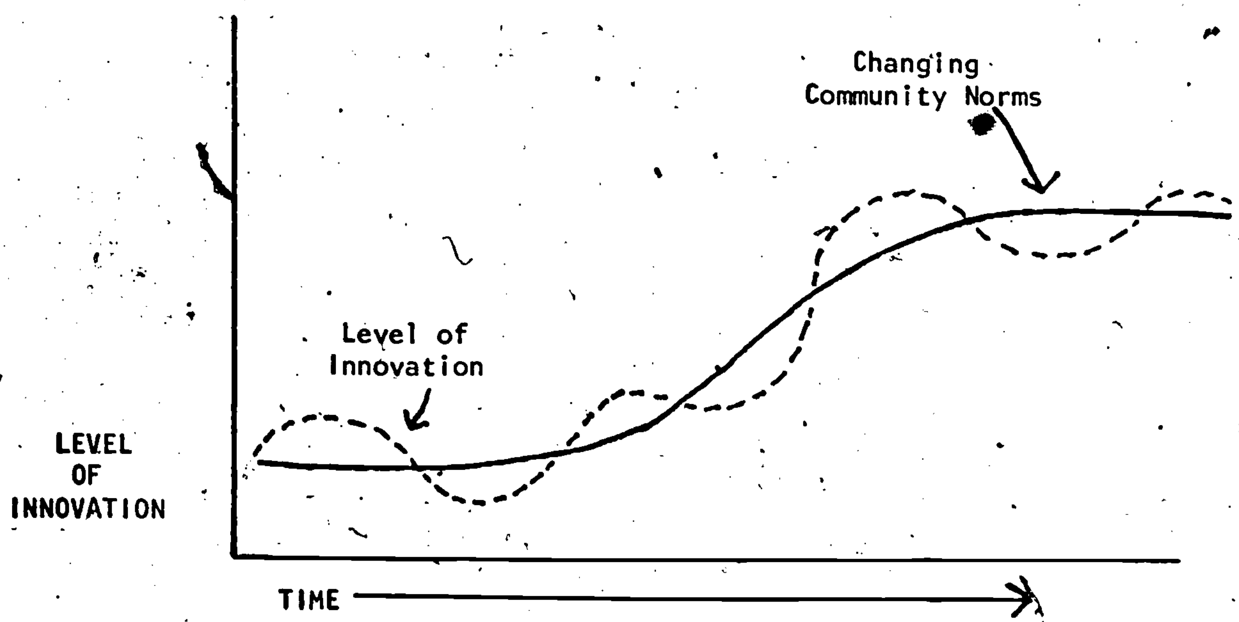

Fig. 3. Reference Behavior Mode: The Transitional Community.

Thus, the first-order evaluation of model validity was based upon two criteria: (1) The ability of the model to reproduce two empirical reference behavior modes: (a) under conditions of stable community norms and (b) under conditions of transitional community norms and (2) the perceived consistency of the model with the experience of groups of teachers, school administrators, educational change agents, professors of education, and system dynamicists.* Assessment of the heuristic value of the model was based upon its utility in understanding the systematic effects of several historically relevant policy strategies for stimulating innovations in public schools. Policies examined include external funding, networking, and programs to enhance leadership effectiveness in education. Efforts were also made to assess the relative effects of dramatic vs. incremental strategies of intervention.

THE MODEL

BACKGROUND TO THE MODEL

The thrust of an extensive literature on educational change has been to portray the force field of educational innovation in strongly disaggregate form.** Variables which impact upon the success or failure of attempts to implement innovations in schools have been put forth in intricate detail from several disciplinary perspectives: sociology (Baldridge and Deal, 1975; Gross, et. al., 1971; Sarason, 1971), social psychology (Bennis, et. al., 1976) and political science (Baldridge, 1972; Iannaccone & Lutz, 1970) documenting the complexity of educational change.

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* System dynamicists are researchers and policy analysts trained in the modeling perspective and method. System dynamics was originally developed at M.I.T. by Prof. Jay W. Forrester. It has been applied for twenty years to policy problems in business, economics, and other fields by system dynamicists at M.I.T., Dartmouth, and other institutions, primarily in the United States and Europe.

** A number of major reviews have become available in recent years (Fullan & Pomfret, 1977; Gaynor, 1977; Giacquinta, 1973; Havelock, et al., 1969 (b); Maguire, et al., 1971; Paul, 1977).

A case study literature is also beginning to emerge. Each case tends to emphasize a different factor or set of factors in accounting for the failure of specific innovations. (Baldridge & Deal, 1975, pp. 389-523; Charters & Pellegrin, 1972; Greenwood, et. al., 1975; Gross, et. al., 1971; House, 1974; Wolcott, 1977).

Theoretical reviews of the literature (Havelock, et. al., 1969) and companion guides to effective practice (Havelock, 1973) reinforced for the reader a permutational view of educational change. According to this view, the success or failure of an innovation is dependent upon the particular mix of a seemingly infinite number of discrete factors: tradition, values, leadership, personality, conflict and conflict resolution, training, supervision, politics, organizational complexity, authority relationships, environmental complexity, interpersonal skills, communications, etc.

The strength of the existing literature on educational change is in the richness of the detail with which it informs the reader's understanding of the complexities of the organizational change processes. This understanding is clearly an essential one.

The fundamental weakness of the existing literature is its inability to explain in directly comprehensible terms the long-term behavior of educational systems with respect to innovation. The focus of the empirical work has been upon innovativeness in the short range, not upon understanding the dynamics of innovation in schools over periods of time much beyond one to five years. Most of the research which has been done has focused upon discrete innovations (team teaching, the catalytic teacher model, Project Plato, etc.) and has not sought to document patterns of innovation within long time frames. In fact, as indicated earlier, baseline data are not available which attempt to describe the ebb and flow of innovation in the American public schools over periods of fifty years or more.

The intent of the Public Schools Change Model is to re-aggregate many of the micro variables described in the literature and to represent, using a relatively small number of critical variables, a dynamic theory of change which can account for the historic oscillations in school districts with respect to educational innovation. The attempt is to describe the structure (i.e. the set of relationships among variables) which gives rise to the

known behavior.*

BASIC ELEMENTS OF THE MODEL

Five factors were identified in the literature and in the policy actions of public and private agencies which are hypothesized to affect interactively on the level of innovation in a public school district. The five factors are Leadership Effectiveness (LE), Support for Innovation (SFI), Conflict (CON), External Funds (EF), and External Linkage (LINK). Support for innovation is conceived of as being derived from leader, professional, and community norms. The modeling task consisted of the identification of these factors and of the specification of the structural configuration of relationships among them to reproduce the two reference behavior modes posited in Figures 2 and 3 (Supra, pp. 4 and 5).

INNOVATION: DEFINITION OF THE TERM

To this point in the discussion, the term "innovation" has been used in a general sense. It is important, however, both for modeling purposes and for reader clarity, to define the concept more precisely. There comes, then, a difficult task: to define the term with heuristic precision, yet not so narrowly that generality of application is impaired.

In developing the model, innovation was conceived of as referring to any dimension of the educational program which could be conceptualized scalarly over time. So, for example, one could conceive of "individualized instruction" in such a fashion; that is, one could conceive of the concept being operationally defined so that it would be possible to observe and estimate the proportion of the school day, week and year (in terms of individual student hours of instruction) which was individualized according to the opera-

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* The structure is described in a set of equations (Appendix B) using the Dynamo II programming language (Pugh, 1976). The methodology of system dynamics is described in a number of published books and articles (e.g. Alfeld and Graham, 1976; Forrester, et. al., 1976; Meadows, et. al., 1974; Randers and Ervik, 1977) and unpublished papers (e.g. Anderson, n.d.; Mass & Senge, 1976; Richmond, 1976; Richmond, 1977; Gaynor, 1977 (a), pp. 1-16).

tional definition. Thus one could imagine 0-100% of the educational program being individualized at any point in time. Following this line of thought, one could further conceive of "individualized instruction" in a school or school district as a continuous variable over time, such that the level of "individualized instruction" could rise and fall, perhaps several times, within a fifty year time frame.*

It should be evident that the focus theoretically is deeply empirical, if ideally so. The theoretical concern is to account for events (innovations) which are significantly related to the regularities of the educational function of schools which, at least ideally, can be operationally defined and empirically observed. It seems to make consumate good sense to talk about what has happened to the level of individualized instruction in public schools during the last fifty years and to seek to understand the generic structure which affects the adoption, inplementation, institutionalization, and discontinuation of that innovation over time.

It is critical that the definition of an innovation as "a dimension of the educational program which can be conceptualized scalarly as a continuous variable over time" is not limited to individualized instruction or any other nominal innovation. It could just as easily refer to team teaching, racial integration, or non-graded instruction. The point is that any significant educational innovation engages important social and professional values, that any such innovation is usefully viewed not simply in terms of an attempt to implement a discrete package in a cross-sectional time frame, but more significantly, as an attempt to alter

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* It is recognized that consideration is not given in this discussion to the difficult problems of measurement in the empirical sense. The reader is asked to acknowledge that something called "individualized instruction" could be defined and measured at least theoretically. Whether this can be done in practice, either politically or technically, is not strictly relevant to the modeling task. In fact, the political processes involved and the conflict engendered in actually defining and operationalizing such innovations are part of the behavioral dynamic, itself, part of the configuration of pressures which produces oscillation over time.

a functional dimension of the educational program, a basic regularity of the school (Sarason, 1971).** Viewed from the latter perspective, the process of innovation is seen as a continuous one replete with progress and backsliding. Schools change and schools change back. Schools implement and discontinue innovations over long periods of time.

BASIC STRUCTURE OF THE MODEL

The Positive Loop

It has been an enduring belief among policymakers as well as among students of the innovative process that several basic elements constitute positive catalysts in support of innovation. It has been widely held that three elements in particular are critical for the successful implementation of significant change in schools.

** It is recognized here that this approach to defining innovation differs from that of the many researchers who think of an innovation as "something new" to the school. Those who conceive innovation in terms of novelty have difficulty in conceptualizing innovation and discontinuation as continuous processes over long periods of time. Rather, an innovation is, according to this definition, short-lived. Thus, these researchers tend to think of schools in terms of innovativeness, whereas the concept employed here is that of level of innovation.

Given the nature of the problem which is under exploration in this paper, the use of the latter concept is crucial. What has been observed is that schools don't seem to change very much over long periods of time. Presumably, those who report this persistent stability in the face of reform are noting that certain characteristics or regularities of the school seem to remain essentially consistent. To score innovativeness in a school in a manner which credits each shift to and fro on any dimension as a mark of innovativeness is to invalidate that score as a measure of long-term change in the character of schooling. But it is precisely the apparent incapacity of schools to alter the character of schooling in the long-term which is the essence of the problem at hand.

The first of these elements is external funding. The provision of external funds has been the mainstay for decades of policymakers in government and private foundations seeking to stimulate and facilitate change in schools.

The second of these elements is leadership effectiveness. Support for pre-service and in-service preparation programs for educational administration represents an ongoing manifestation of belief in leadership as a critical element in educational reform. The Educational Professions Development Act (EPDA) illustrated more acutely the policymakers' faith in the leadership component of educational change during the late sixties and early seventies.

The third critical element is external linkage. It has been widely held (Carlson, 1965; Gouldner, 1957-58) that cosmopolitan leadership (i.e., leadership substantially linked to external reference groups) is more likely to be influential in support of innovation than is leadership not so linked. The current thrust of the National Institute of Education (NIE) in support of networking is consistent with faith in external linkage as an important catalyst of innovative behavior in schools.

Built into the model is a set of assumptions about the structural relationships among external funding, leadership effectiveness, external linkage, and innovation. As depicted in the following diagram (Fig. 4), this structure, consistent

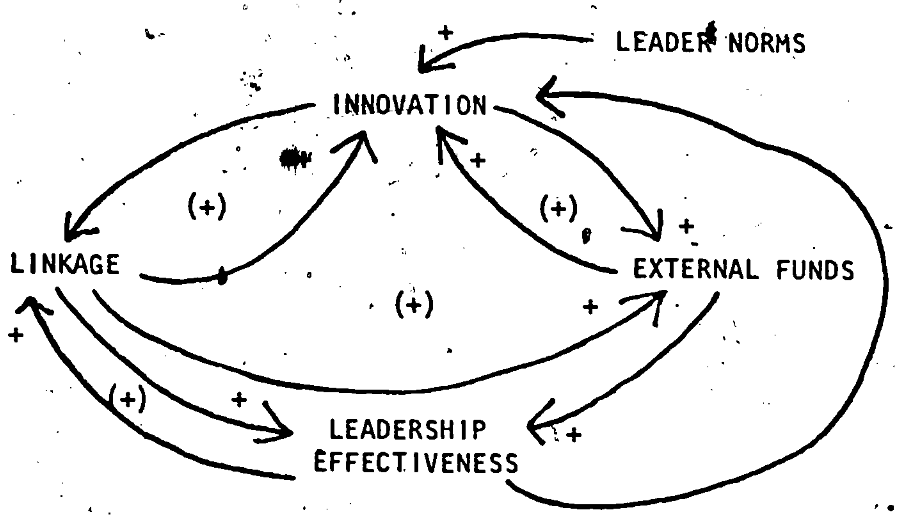

Fig. 4. The Positive Loop

with historic policy, is seen to be a positive, or mutually reinforcing one. As indicated by the signed arrows,* increases in each of the elements tend to generate (cause) increases in the other elements and decreases in each of the elements tend to generate decreases in other elements.**

The effect of this assembly of positive loops is, of course, to drive innovation up, up, up or down, down, down, depending on which way things get going. Obviously, the way "things get going" at any point in time is partly dependent upon external (exogenous) events in the environment (e.g., the economy or presidential politics) and partly dependent upon other structural relationships (other loops) in the system.

The model is based upon the theoretical assumption that a significant part of the behavior of this positive loop is determined by its structural interaction with other loops in the system. The model is also designed

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* An arrow depicts the theoretical effect of one variable upon another. This effect is portrayed in the diagram under the ceteris paribus assumption (i.e., where everything else is assumed to be equal). When the sign at the head of the arrow is plus (+), the indication is that a change in the first variable (at the tail of the arrow) causes a change in the second variable (at the head of the arrow) and that the change in the second variable is in the same direction as the change in the first variable (up or down as the case may be). A negative sign (-) at the arrowhead indicates that a change in the first variable (up or down) causes a change in the second variable in the opposite direction (down or up). It is important to note that a given criterion variable may be affected within an entire system by multiple causal variables. Thus, the actual behavior of the criterion variable over time cannot be understood without knowing the causal effects of all of the variables in the multiple feedback system. This is why complex systems tend to behave in counterintuitive ways and why computers are useful in tracking the large number of multiple effects over time.

** Note that the arrow from leadership effectiveness to innovation is unsigned. The reason for this is that the effect of leadership effectiveness upon innovation depends upon the relative position of leader norms at each point in time. This position determines whether leaders work for or against innovation.

to test the effects upon the system* of certain external events (exogenous inputs) which take the form of policy interventions (e.g., systematic changes in external funding, external linkage, leadership effectiveness or implementation of innovative practices over some period of time).

Operating alone (i.e., out of context with other loops in the system), the positive loops would tend to increase the level of innovativeness in the school system given any increase in external funding, leadership effectiveness, or external linkage. In fact, it has been precisely in anticipation of this "snowball effect" that, over the years, policymakers interested in changing schools have put large amounts of money at stake, underwritten leadership training institutions, and supported educational collaborations of one kind and another.

It is interesting to note that in this loop the model subscribes explicitly to the assumptions underlying the major policy directions of the last two decades. Yet, as we know, the real world behavior of school systems suggests that other forces must be operating to counter the innovative effects of the positive loop; otherwise, the empirical findings with respect to innovation in schools would be more sanguine. Thus, it was imperative in the conceptualization of the model to represent additional pieces of structure to account for the actual behavior of real world school systems.

<u>Negative Loop I</u>

There are two other structural subsystems which have been incorporated into the model. Both of these are assemblies of negative feedback loops.** They operate to provide <u>compensating responses</u> to the driving effects of the positive loop in order to maintain in the system a centralizing

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* A system is a set of structural relationships represented (1) as an assembly of causal loops and (2) as a set of mathematical equations.

** A negative feedback loop is a circular configuration of causal relationships which contains an uneven number of reversals (negative relationships). The effect of this condition is to create a <u>stabilizing structure</u> much like a thermostat system which constantly compensates over time with responses which tend to prevent the system from moving very far from some central point (e.g., the setting on a thermostat).

tendency. They represent, in a technical sense, the conservative dynamic in school systems, those forces which tend to keep educational programs pretty much as they are over long periods of time.

The first of the two negative loop assemblies can be called the political subsystem. It represents in highly aggregate form the essential dynamics of the political system surrounding schools (Easton, 1965).

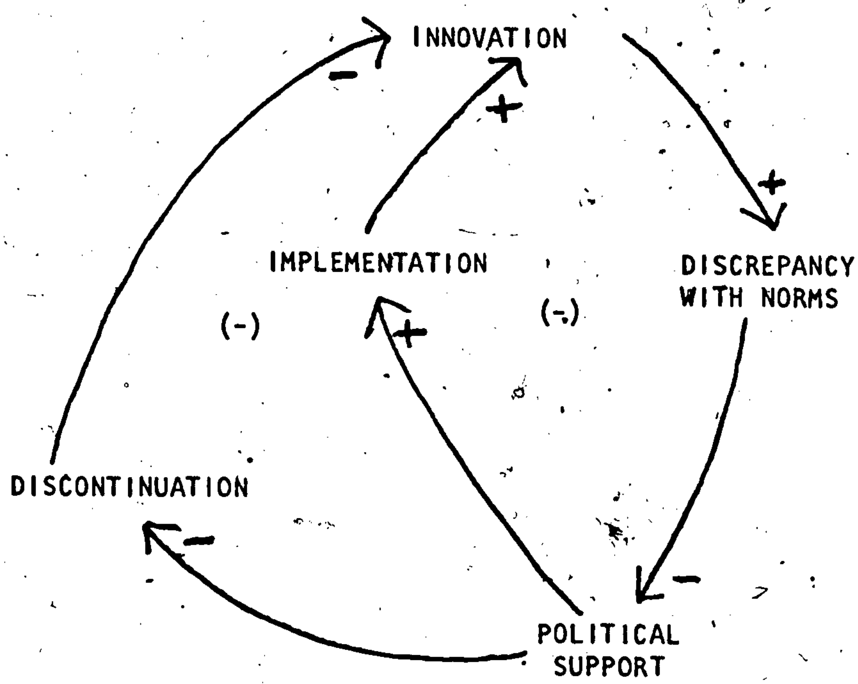

Fig. 5. Negative Loop I.

According to this representation, an innovation represents a change in one direction or the other on some appropriate scale (e.g., percent of the educational program embodying that characteristic - individualized instruction, racial, integration, etc.) on some significant dimension of the educational program. Such a change constitutes in real life a discrepancy with existing norms (educational values shared within the political constituencies of the school: teachers, leaders, citizens). As awareness of this discrepancy grows (time delay), latent actors become active and political

support against the innovation grows (Weiser, 1976). The impact of negative political support is to suppress further implementation and to exacerbate backsliding toward old ways (discontinuation).

The effect of this double dynamic is to return the educational program to a state consistent with prevailing educational norms.* It does this by operating directly upon the rates of implementation and discontinuation. However, because of the interactive nature of the feedback networks, indirect effects are felt upon the positive loop. The effects of the negative loops upon the positive loop cause the positive loop to drive upward and downward, toward more or less innovation, at different points in time. Since the relationships among the loops tend to be delayed in time, compensating responses to norm discrepancies are delayed, also. The result is oscillation over time with respect to innovation.

Negative Loop II

Both the theoretical literature (Kahn, et. al., 1964; Klein, 1976) and empirical case studies (Bredo, 1978; Levin & Simon, n.d.; Wacaster, 1975; Weiser, 1976; Wolcott, 1977) document a second important negative loop which tends to stabilize school systems against innovation. This loop describes a feedback system around the interactive effects of innovation and conflict.

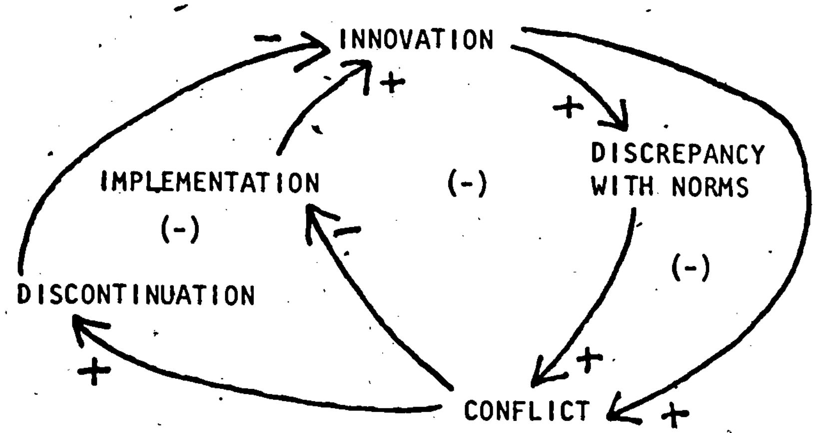

Fig. 6. Negative Loop II.

* Note that the effect of this dynamic is reactionary with respect to progressive innovations and progressive with respect to reactionary innovations.

Innovations press teachers, administrators, and others within the school system to adopt new role behaviors. These new behaviors often require new skills (Carlson, 1965; Gross, et. al., 1971), new social arrangements (Iannaccone, 1964), new cognitive orientations (Charters and Jones, 1975; Wolcott, 1977), and increased work loads with dubious benefit/cost implications (Wolcott, 1977). The result, typically, is a growing discrepancy between existing work norms* and those associated with the innovation. This discrepancy tends to generate conflict which, like political countervalence, has the effect of slowing further implementation and of intensifying the erosion of existing implementation (discontinuation), both of which tend to return the system to "normal".

Thus, the conflict loop, like the political loop, operates to stabilize the system against innovation. Essentially, innovation generates conflict which suppresses innovation. The effects of the conflict loop assembly are in interaction with other sub-systems of the model. For example, leadership effectiveness is seen as impacting upon conflict. The more effective leadership is, the more effective the problem-solving and conflict resolution in the school system. In this way, a result of effective leadership is to reduce conflict.** It is also true that conflict, like politics,

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* c.f., the term "role expectations": Getzels, et. al., 1968.

** It should be pointed out that, conceptually, leadership is used in the model not simply as a property associated with an individual (e.g. the superintendent or principal) but as a <u>system property</u>. The distinction is a fundamental one which has strong implications for understanding the dynamics of school systems. These implications have been partially explored by the system dynamics seminar in the Boston University School of Education and in conversations with others who have attended presentations of the model during the spring of 1978. The thrust of this paper, however, is to describe the model and to report the results of policy experiments using the model. Therefore, further discussion of leadership, its definitions and implications, will be postponed to another forum. However, it does seem appropriate to note that the precision associated with the modeling process, in the specification of structural relationships, does tend systematically to raise significant substantive issues with broad theoretical implications.

has important effects upon the positive loop and helps to determine the extent to which, at any point in time, the positive loop produces pressure for more or less innovation.

There is an important variation in the dynamics of the conflict loop which is unique. An important representation in the model has to do with the effects of conflict upon the implementation and discontinuation of innovations in the school system. To this point, the relationship between conflict and innovation has been described as uniformly negative. Increases in conflict have been portrayed as consistently supressing the rate of implementation and increasing the rate of discontinuation of innovations.

The suggestion of relationships among these variables which are essentially linear in nature is inconsistent with commonly accepted theory. Kurt Lewin's concept of "unfreezing", for example, suggests that a little conflict is a good thing with respect to change. The import of Lewin's theory is that some conflict promotes the implementation of change, with little effect upon discontinuation. This theoretical perspective has been incorporated into the model. It is depicted in the rate-level graphs shown below. (Figs. 7 & 8).

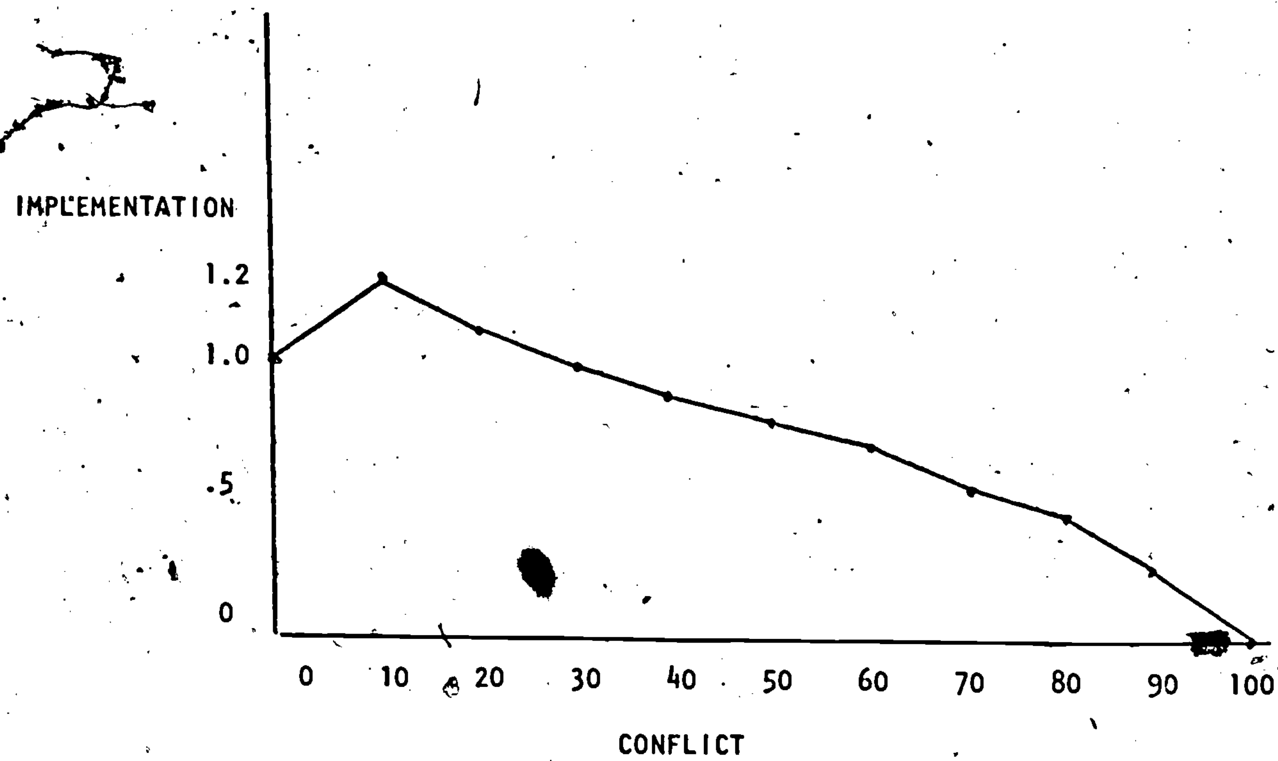

Fig. 7. Rate-Level Graph: Effect of Conflict upon Implementation.

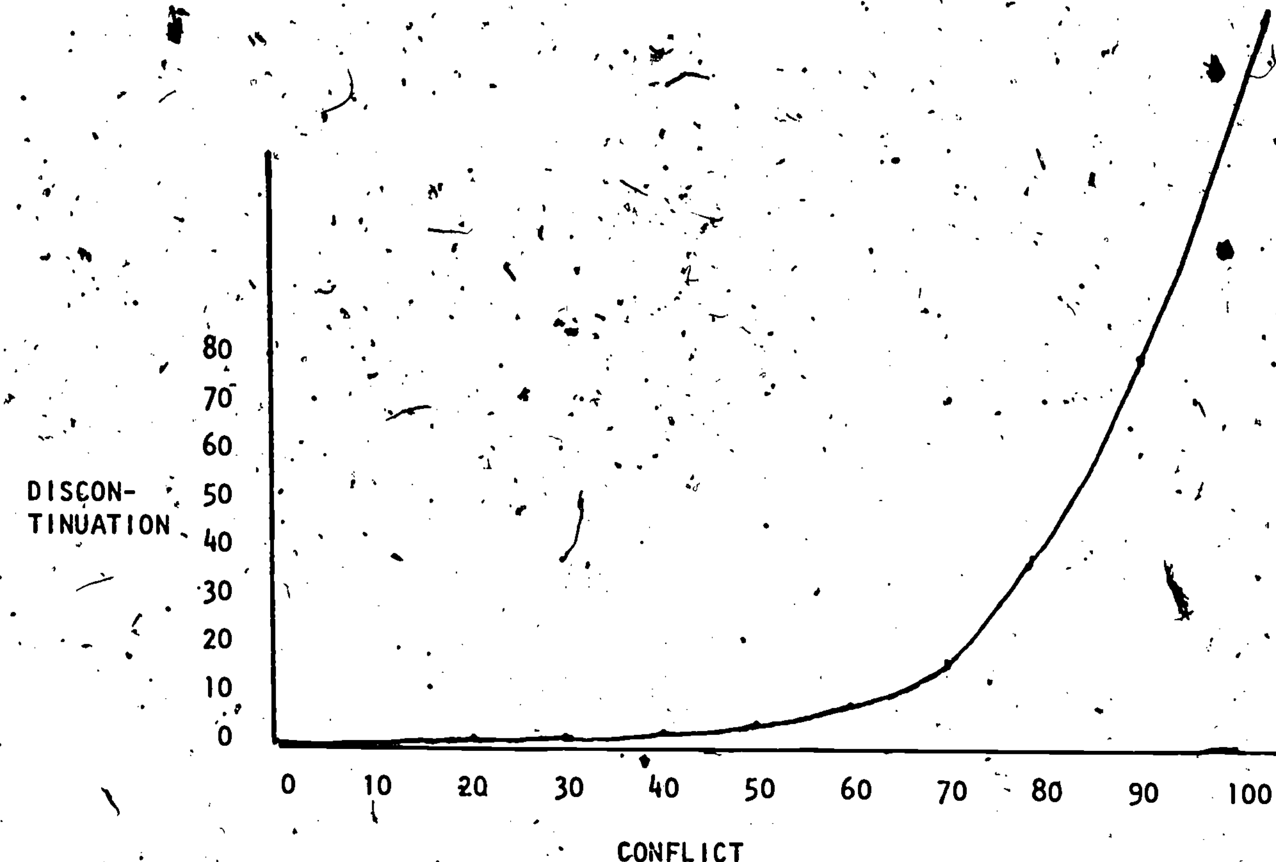

Fig. 8. Rate-Level Graph: Effect of Conflict upon Discontinuation.

Note (Fig. 7) that moderate levels of conflict have a positive impact upon implementation and that it is only high levels of conflict which suppress implementation. Note, too (Fig. 8), that the rate of discontinuation is affected little by moderate levels of conflict, but that further intensification of conflict affects the rate of discontinuation exponentially.*

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* Precise structural relationships are expressed throughout the model in mathematical equations which can be represented visually in graphs such as these. Thus, the rate-level graphs shown here (Figs. 7 & 8) not only depict the specific relationships discussed but also illustrate the system dynamics methods of depicting relationships among variables. Relationships are also displayed visually in flow diagrams which are more detailed than causal-loop diagrams, although not as precise as the equations, themselves. The flow diagrams for the Public Schools Change Model have been included in Appendix A. The equations are listed in Appendix B.

RESULTS

CONTROL AND EXPERIMENTAL CONDITIONS IN MODEL TESTING

A major advantage of using a computer simulation model for purposes of policy analysis is that alternative policies can be tested under conditions free of uncontrolled variation. Once the program has been written and debugged, the model describes, in a purposefully parsimonious way, the structural relationships which are believed to give rise to the particular behaviors of the real world system which the model was constructed to explain. The parameters of the model can then be initialized to produce what is called a state of dynamic equilibrium. In this state, the rates of increase and decrease of each variable are equal,* and therefore, the values of the variables remain constant throughout the run of the model (Fig. 9) or until an exogenous input throws the model out of equilibrium.

It is, of course, precisely this latter condition which is the experimental condition. Each policy alternative to be examined is formulated as an exogenous input. Then, this input and no other is fed into the model. Given the structure of the model, the resulting change in its behavior can then be attributed uniquely to this policy input and no other cause.

Figure 9 displays a computer printout of the values of the model over a fifty year time period.** This printout shows the system in a state of dynamic equili-

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* Note that these rates are typically not zero. In a state of dynamic equilibrium, it is not that nothing is happening but rather that inputs and outputs throughout the model are evenly balanced. The result is a set of values of the variables in the model which do not change over time. (See Fig. 9)

** The time period has been set arbitrarily at 1970-2020.

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PAGE 1   FILE SYSIN   DYNAMICS OF CHANGE IN SCHOOLS MODEL --A.K.GAYNOR
LOI=X,PPN=P,PLN=L,PCN=C,EF=F,LINK=Y,LE=E,CON=Z,SFI=S.
          .0            25.            50.            75.           100. XPLC
          0.           250.           500.           750.          1000. F
          .0            25.            50.            75.           100. YEZ
       -100.           -50.            .0             50.           100. S
   1970.ZF- -X- - - - - - - - - - - - S - - - - - - - - - - - - - - XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
   1980.ZF- -X- - - - - - - - - - - - S - - - - - - - - - - - - - - XPLCYE
        ZF   X                        S              .              . XPLCYE
        ZF   X                        S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
   1990.ZF- -X- - - - - - - - - - - - S - - - - - - - - - - - - - - XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
   2000.ZF- -X- - - - - - - - - - - - S - - - - - - - - - - - - - - XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
   2010.ZF- -X- - - - - - - - - - - - S - - - - - - - - - - - - - - XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
        ZF   X        .               S              .              . XPLCYE
   2020.ZF- -X- - - - - - - - - - - - S - - - - - - - - - - - - - - XPLCYE
```

Fig. 9. Computer Run: The Model in Equilibrium.

brium.* The equilibrium condition constitutes a starting point for each subsequent policy test. It constitutes what, in experimental design, is called the control condition.

THE VARIABLE SCALES

The scales are in units of 0-100, except for the External Funds Scale, which is in units of 0-1000, and the Support for Innovation Scale which, conceptually, can be negative as well as positive. The SFI scale is in units of -100 to +100. Since the model is intended to examine the relative behavior of the system over time, units do not attempt to reflect actual real world values. However, there are relationships among these units which are central to the model.

The External Funds (f) Scale is more than large enough to handle the actual outcomes of any of the test runs. EF cannot logically be less than zero.

External Linkage (Y), Leadership Effectiveness (E), and Conflict (Z) represent variables which, also, cannot logically take on values lower than zero. Each is scaled in the model to a top value of 100 which represents, in an abstract way, the highest amount of linkage, effectiveness or conflict which is conceivable in the real world.

Support for Innovation (S) includes, conceptually,

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* The symbols read as follows:

X = Level of Innovation (LOI)
P = Progressivism of Professional Norms (PPN)
L = Progressivism of Leader Norms (PLN)
C = Progressivism of Community Norms (PCN)
F = External Funding (EF)
Y = External Linkage (LINK)
E = Leadership Effectiveness (LE)
Z = Conflict (CON)
S = Support for Innovation (SFI)

Note that when two or more variables should be printed out at the same point on the graph, the computer prints only one of them and indicates at the right the other variables which occupy the same point. For example, in Figure 9, P, L, C, Y and E occupy the same position on the graph as X.

both support for and opposition to innovation. Therefore, the scale includes a negative as well as a positive side. The concept of limits is similar here to that discussed in the preceding paragraph except that it applies to both the upper and lower ends of the scale.*

Perhaps most central to the model, are the relationships among four scales: Level of Innovation (X), Progressivism of Professional Norms (P), Progressivism of Leader Norms (L), and Progressivism of Community Norms (C). The dynamic that drives the level of Support for Innovation (S) is tied to discrepancies among LOI (X), PPN (P), PLN (L), and PCN (C). Therefore, these variables must be calculated in precisely the same units (so that in figuring the discrepancies, the computer is not subtracting "apples and oranges").

The unit which is used is one which was alluded to briefly in an earlier section of the paper (supra p. 14) An innovation is conceived of as comprising a certain portion of the educational program (0-100%). Thus, the level of innovation (X) is scaled from 0-100. Norms are conceived of as educational values which are shared, respectively, among teachers, leaders and citizens. These educational values are directed toward innovations, which are perceived by members of these groups as more or less consistent with their values. Thus, with respect to any given innovation (e.g., individualized instruction, team teaching, or racial integration), each group's norms are conceived of in terms of <u>that portion of the educational program</u> (0-100%) which that group, on the average, is desirous of having devoted to that innovation. Thus, both the level of innovation and the norms with respect to the level of innovation are measured on the same scale (0-100) and in the same units (percent or the educational program devoted to or desired to be devoted to the innovation).

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* The top value represents, simply, an upper limit in each case beyond which there are no either feasible or imaginable values in the real world. In the model, further increases approaching these limits become infinitely difficult. These limits are intended to represent real world forces operating to sustain some limits, at least if the system is to remain intact. The construct of limits raises difficult issues, many of which remain unresolved. Since these issues relate mainly to extreme cases in the real world, the limit variables have been retained in the present model for purposes of simplicity.

VALIDITY TESTS OF THE MODEL

Face Validity

The face validity of the model is ultimately a matter of decision for each reader. However, the model has been presented to a number of groups with different perspectives on educational change and on the modeling process. These groups include the following: (1) educational researchers at the 1977 annual meeting of the Northeastern Educational Research Association (preliminary model), (2) teachers and building administrators at a principals' workshop in Bethlehem, Pennsylvania, (3) teachers and administrators in the Wayland, Massachusetts school system, (4) students in System Dynamics and Educational Organizational Analysis at Boston University, (5) staff members of the Institute for Responsive Education at Boston University, (6) staff members of the Wisconsin Research and Development Center for Individualized Instruction, and (7) advanced doctoral students in System Dynamics at the Sloan School of the Massachusetts Institute of Technology. Results from the discussions following these presentations suggest that there are important conceptual issues which the model raises and which are as yet not fully resolved, especially around such constructs as leadership and limits (c.f., Supra, pp. 16 and 22). They also suggest general satisfaction with the model structure and with the theory of stability and change which that structure represents. Positive reactions have been expressed by both educators and system dynamicists.

Empirical Validity

The face validity data are encouraging but distinctly impressionistic. The critical test at this point in time is the ability of the model to reproduce the reference behavior modes shown in Figures 2 and 3. The results of these tests are displayed in Figures 10 and 11.

REPRODUCING HISTORICAL BEHAVIOR UNDER CONDITIONS OF STABLE COMMUNITY NORMS

In order to evaluate the behavior of the model under something approximating normal conditions over a long period of time, the model was put in a condition of dynamic equilibrium and then subjected to slightly correlated, mainly random changes in all of the model variables within a fifty year time frame (shown in the printout as 1970-2020) (Fig. 10).

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E 1   FILE SYSIN   DYNAMICS OF CHANGE IN SCHOOLS MODEL --A.K.GAYNOR

=X,PPN=P,PLN=L,PCN=C,EF=F,LINK=Y,LE=E,CON=Z,SFI=S

      .0          3.75          7.5          11.25          15. X
      .0           25.          50.           75.          100. PLCFYEZ
   -100.          -50.          .0            50.          100. S
1970.Z - -P- - - - - - - - - - - S - - - - -X- - - - - - - - - - PLCFYE
     Z   FP         .            S          X    .             . PLCYE
     .Z   P         .            S          X    .             . PLCFYE
     .Z   P         .            S          X    .             . PLCFYE
     .Z  FPY        .            S         X     .             . PLCE
     .Z  FP         .            S         X     .             . PLCYE
     .Z F P         .            S        X      .             . PLCYE
     .Z F P         .            S         X     .             . PLCYE
     .Z FEPC        .            S         X     .             . PL,CY
     Z  FEPY        .            S         X     .             . PLC
1980.-Z-F-PC - - - - - - - - - - S - - - - X - - - - - - - - - - PLYE
     .Z F PL        .            S         X     .             . LC,PYE
     .Z  FPL        .            S           X   .             . LC,PYE
     .Z  FPL        .            S            X  .             . LC,PYE
     .Z  FPL        .            S             X.              . LC,PYE
     .Z  FPL        .            S               X             . LC,PYE
     .Z  FPLC       .            S               X             . LY,PE
     .Z  FPLC       .            S             X.              . LY,PE
     Z  F PLC       .            S               X             . LY,PE
     Z  F PLC       .            S               X             . LY,PE
1990.Z -F-PLC- - - - - - - - - - S - - - - - - X - - - - - - - - LY,PE
     Z  F PLC       .            S               X             . LY,PE
     Z  F PLC       .            S               X             . LY,PE
     Z   FEPC       .            S               X             . PLY
     .Z  FEPC       .            S               .  X          . PLY
     .Z   FPC       .            S               .   X         . PLY,FE
     .Z  FEPC       .            S               .   X         . PLY
     .Z  FEP C      .            S               .  X          . PLY
     Z   FEPLC      .            S               . X           . PY
     Z   FEPL       .            S               .X            . LC,PY
2000.Z - FEPLC - - - - - - - - - S - - - - - - - - X - - - - - - PY
     Z   FEPLC      .           .S               . X           . PY
     .Z  FEPLC      .           .S               . X           . PY
     Z   FEPLC      .           .S               . X           . PY
     Z   FEPLC      .           .S               . X           . PY
     Z   FEPLC      .           .S               . X           . PY
     Z   F PLC      .           .S               . X           . PY,FE
     Z   F PLC      .           .S               . X           . PY,FE
     Z   FEPLC      .           .S               X             . PY
     Z   FEPLC      .           .S               X             . PY
2010.Z - FEPLC - - - - - - - - -S- - - - - - - X- - - - - - - - PY
     Z   FEYPC      .           .S               .X            . PL
     .Z   FYPC      .           .S               .X            . PL,FE
     .Z   FPLC      .           .S               .X            . PY,FE
     .Z   FPLC      .           .S               . X           . LY,FE
     .Z   FPLC      .           .S               .X            . PY,FE
     .Z   FPLC      .           .S               X             . PY,FE
     .Z   FPLC      .           .S               X             . PY,FE
     .Z   FPLC      .           .S             X.              . PY,FE
     .Z   FPLC      .           .S             X.              . PY,FE
2020.-Z- -FPLC - - - - - - - - -S- - - - - X- - - - - - - - - - PY,FE
```

Fig. 10. Computer Run: Pink Noise with Stable Community Norms.

The exogenous input representing the test condition is known as "pink noise." It was intended to represent in the simulated run the effects over time of normal environmental noise on the school system. All scales are as described earlier except the level of innovation scale (X), this was modified (0-15) to make clearer the pattern of behavior where the range of oscillation was less than five percent on a scale of one hundred.

It is the pattern which has been depicted in the reference mode; therefore, it is the pattern which must be evaluated for fit. The model does reproduce the oscillations noted historically in the real world behavior of public school systems with respect to innovation.

REPRODUCING HISTORICAL BEHAVIOR UNDER CONDITIONS OF TRANSITIONAL COMMUNITY NORMS

Once it was established that the model would reproduce historically known behavior in the real world under conditions of stable community norms (i.e., no exogenous change in community norms), it was necessary to test further the ability of the model to reproduce historically known behavior in the real world under conditions of changing community norms (c.f., Fig. 3 Supra, p. 5). The results of this test are displayed in Figure 11.

In this run, only pink noise conditions are operative until 1975, at which point community norms (C) begin to rise gradually from an initial value of ten to a new value of thirty. As expected, the level of innovation (X) lags, then rises also to levels consistent with the emergent community norms. It is interesting to note, also, that during the period of transition, conflict levels (Z) are elevated until the system reestablishes itself in oscillation around the new norms and that professional (P) and leader (L) norms rise, too, to levels consistent with changing community values. The dynamics of the school system seem essentially consistent with the reference modes (Fig. 3) and with empirical events in transitional communities (Iannaccone & Lutz, 1970, pp. 69-233).

POLICY ANALYSES

Effects of External Funding

Two tests were run to examine the impact upon the

PAGE 1   FILE SYSIN   DYNAMICS OF CHANGE IN SCHOOLS MODEL --A.K.GAYNOR   8/22/

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LOI=X,PPN=P,PLN=L,PCN=C,EF=F,LINK=Y,LE=E,CON=Z,SFI=S .

     -10.           2.5         15.          27.5          40. X
      .0            25.         50.           75.         100. PLCFYEZ
    -100.          -50.          .0           50.         100. S
1970.Z - -P- - - - - - - - -X- - S - - - - - - - - - - - - - - PLCFYE
     Z   FP         .       X    S            .            . PLCYE
     .Z   P         .       X    S            .            . PLCFYE
     .Z   P         .       X    S            .            . PLCFYE
     .Z  FPY        .       X    S            .            . PLCE
     .Z  FP         .      X     S            .            . PLCYE
     .Z F P         .      X     S            .            . PLCYE
     .Z F PC        .       X    S            .            . PLYE
     .Z FEPC        .       X    S            .            . PL,CY
     .Z FEPC        .       X    S            .            . PL,CY
1980.-Z-F-PLC- - - - - - - X - - S - - - - - - - - - - - - - - PYE
     .Z F PLC       .       X    S            .            . PYE
     .Z  FPL C      .       X    .S           .            . PYE
     .Z  FP L C     .       X    .S           .            . PYE
     .Z  FP L  C    .        X   . S          .            . PYE
     .Z  FP  L  C   .        X   .  S         .            . PYE
     .Z  FEP  L  C. .        X   .   S        .            . PY
     .Z  FEP  L    .C         X  .    S       .            . PY
     Z   FEP   L   . C        X  .      S     .            . PY
     Z   FEP    L  .  C        X .        S   .            . PY
1990.-Z- FEYP- -L- - C - - - - X - - - - - - S - - - - - - - - 
     .Z    F P    L.  C         X.             S.           . PY,FE
     .Z    EFYP    L  C          X             S.           .
     . Z   E FP    L  C          .X             S           . FY
     . Z   E  YP   L  C          .   X          S           . PF
     . Z   E    PF L  C          .      X      S.           . PY
     .  Z E     YP L  C          .         X S  .           . PF
     .  Z E      P L  C          .          X   .           . PFY,XS
     .  Z E      P L  C          .        S   X .           . PFY
     . Z  E     FYP .L C         .      S      X.           .
2000.- Z -E- -F-P- L C - - - - - - S - - - - -X- - - - - - - - PY
     . Z  E     F YP. LC         . S            . X         .
     . Z  E     FY  P LC         .S             . X         .
     .Z   E     F Y P LC         S              .  X        .
     .Z   E     F Y P LC         S              .  X        .
     .Z   E     F Y .P L         S              .  X        . LC
     .Z   E     F Y .P L         S              .  X        . LC
     .Z   E     F Y . PL         S              .  X        . LC
     .Z   E   F   Y . PL         S              .  X        . LC
     .Z   E   F   Y . PL         S              . X         . LC
2010.-Z- -E- F -Y- -PL - - - - - S - - - - - - - X - - - - - - LC
     .Z     E F   Y .   P        S              .X          . PLC
     .Z   E   F   Y .   P        S              .X          . PLC
     .Z   E   F.  Y . LP         S              .X          . PC
     .Z   E   F   Y . PL         .S             .X          . LC
     Z      E F   Y . PL         .S             .X          . LC
     Z      E F   Y . PL         .S             X           . LC
     Z      E F   Y . PL         .S             X           . LC
     Z      E F   Y . PL         .S             X           . LC
     Z      E F   Y . PL         .S             X           . LC
2020.Z - - E F -Y- -PL - - - - - -S- - - - - - X - - - - - - - LC
```


Fig. 11. Computer Run: Pink Noise with Changing Community Norms.

school system of external funding as a policy intervention in support of innovation. The tests were identical in that each consisted of an exogenous increase in external funding for a five year period (1975-1980). In the second test, however, the rate of increase was double that in the first test. The results of these tests are displayed in Figures 12 and 13.

One conclusion that can be drawn from this experiment is that most of the effect upon innovation in public school systems of short-term external funds is short-term. The system tends to return the level of innovation toward initial levels in the long run. A second conclusion that can be drawn is that significantly larger amounts of external funding do have an incremental effect beyond those produced by smaller amounts of funding both in the short- and long-term. By and large, however, the system compensates effectively to minimize the marginal effects of external funding alone.

Effects of External Linkage

Two tests were run to examine the effects upon system behavior of policies designed to increase external linkage.* The results of these tests are displayed in Figures 14 and 15.

The long-run effectiveness of external linkage (Y) is supported by the unfettered dynamics of the model during the fifty-year time frame of the first run (Fig. 14). Short-term exogenous increases in linkage (1975-1980), through the internal structure of the model, itself, if temporary, increases in external funding, and lasting increments in leadership effectiveness, norms, and innovation, as well as linkage, itself. Elevations in levels of conflict remain in the functional range and contribute to innovative activity.

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* The concept of external linkage in the model is substantially synonymous with that of networking as it is current in educational policy circles at this time (1978). It implies connection of people in school districts with people in state departments, national and regional association centers and collaboratives, universities, foundations, other school systems, etc. It is strongly related to the concept of cosmopolitanism (Carlson, 1965; Gouldner, 1957-58) and to networks of professional reference groups. Linkage is seen as a source of ideas, values and technical expertise.

PAGE 1   FILE SYSIN   DYNAMICS OF CHANGE IN SCHOOLS MODEL --A.K.GAYNOR

LOI=X,PPN=P,PLN=L,PCN=C,EF=F,LINK=Y,LE=E,CON=Z,SFI=S

```
        .0         3.75          7.5        11.25          15. X
        .0          25.          50.          75.         100. PLCFYEZ
     -100.         -50.          .0           50.         100. S
   1970.Z - -P- - - - - - - - - - - S - - - - -X- - - - - - - - - - - PLCFYE
        Z    P       .            S        X   .            . PLCFYE
        Z    P       .            S        X   .            . PLCFYE
        Z    P       .            S        X   .            . PLCFYE
        Z    P       .            S        X   .            . PLCFYE
        Z    P       .            S        X   .            . PLCFYE
        Z    PF      .            S        X   .            . PLCYE
        Z    P   F   .            S        X   .            . PLCYE
        Z    P       F            S         X  .            . PLCYE
        .Z   P       .    F       S          X .            . PLCYE
   1980.-Z- -PY - - - - - - - - F S - - - - - - -X- - - - - - - PLCE
        . Z  PY      .    F       S            . X          . PLCE
        . Z  PY      .F           S            .  X         . PLCE
        . Z  PY    F .           S.            .   X        . PLCE
        . Z  P Y  F  .           S.            .   X        . PLCE
        .  Z LP F    .           S.            .   X        . LCE,PY
        .  Z LPF     .           S.            .   X        . LCE,PY
        .  Z CPF     .           S.            .   X        . PLY,CE
        .  Z CPF     .           S.            .  X         . PLY,CE
        .  Z CP      .           S.            .  X         . PLFY,CE
   1990.- -Z-CP - - - - - - - - -S- - - - - - - - X - - - - .- PLFY,CE
        .  Z CP      .           S.            . X          . PLFY,CE
        .  Z CP      .           S.            . X          . PLFY,CE
        .  Z CP      .           S.            . X          . PLFY,CE
        . Z  CP      .            S            .X           . PLFYE
        . Z  CP      .            S            .X           . PLFYE
        . Z  CP      .            S            .X           . PLFYE
        . Z  CP      .            S            .X           . PLFYE
        . Z  CP      .            S            .X           . PLFYE
        . Z  CP      .            S            .X           . PLFYE
   2000.- Z -CP - - - - - - - - - S - - - - - -X- - - - - - - PLFYE
        . Z  CP      .            S            X            . PLFYE
        .Z   CP      .            S            X            . PLFYE
        .Z   CP      .            S            X            . PLFYE
        .Z   CP      .            S            X            . PLFYE
        .Z   CP      .            S            X            . PLFYE
        .Z   CP      .            S            X            . PLFYE
        .Z   CP      .            S            X            . PLFYE
        .Z    P      .            S            X            . PLCFYE
        .Z    P      .            S            X            . PLCFYE
   2010.-Z- - P - - - - - - - - - S - - - - - -X- - - - - - - PLCFYE
        .Z    P      .            S            X            . PLCFYE
        .Z    P      .            S            X            . PLCFYE
        .Z    P      .            S            X            . PLCFYE
        .Z    P      .            S            X            . PLCFYE
        .Z    P      .            S            X            . PLCFYE
        .Z    P      .            S            X            . PLCFYE
        .Z    P      .            S           X.            . PLCFYE
        .Z    P      .            S           X.            . PLCFYE
        .Z    P      .            S           X.            . PLCFYE
   2020.-Z- - P - - - - - - - - - S - - - - - X - - - - - - - PLCFYE
```

36

Fig. 12. Computer Run: Increase in External Funding.

LOI=X,PPN=P,PLN=L,PCN=C,EF=F,LINK=Y,LE=E,CON=Z,SFI=S

```
     .0         3.75          7.5        11.25           15. X
     .0          25.          50.           75.         100. PLCFYEZ
  -100.         -50.           .0          50.         100. S
1970.Z - -P- - - - - - - - - - -S - - - -X- - - - - - - - - PLCFYE
     Z    P        .            S        X   .            . PLCFYE
     Z    P        .            S        X   .            . PLCFYE
     Z    P        .            S        X   .            . PLCFYE
     Z    P        .            S        X   .            . PLCFYE
     Z    P        .            S        X   .            . PLCFYE
     Z    P F      .            S        X   .            . PLCYE
     Z    P        F            S        X   .            . PLCYE
     Z    P        .       F    S          X .            . PLCYE
     .Z   PY       .            S    F       X            . PLCE
1980.- Z -P-Y- - - - - - - - - -S - - - - - - - FX- - - - - PLCE
     .  Z P Y      .            S   F        .       X    . PLCE
     .  Z P   Y    .        F  S.            .          X . PLCE
     .   ZLP  Y    .   F       S.            .           X. LCE
     .   ZCP  Y    F          S .            .            X PLE
     .    CP  Y F  .          S .            .            X PLE,CZ
     .    CP  YF   .          S .            .           X. PLE,CZ
     .    CP  F    .          S .            .          X . PLEZ,FY
     .    CP  F    .          S .            .         X  . PLEZ,FY
     .    CPFY     .          S .            .        X   . PLEZ
1990.- - -CLP- - - - - - - - -S - - - - - - - - - - -X- - - PFY,LEZ
     .    CLP      .           S.            .      X     . PFY,LEZ
     .    CLP      .           S.            .     X      . PFY,LEZ
     .    CLP      .           S.            .    X       . PFY,LEZ
     .    ZLP      .           S.            .    X       . LCE,PFY
     .    ZLP      .           S.            .   X        . LCE,PFY
     .   Z PY      .           S.            .   X        . PLCFE
     .   Z PY      .           S.            .   X        . PLCFE
     .  Z   PY     .            S            .  X         . PLCFE
     .  Z   PY     .            S            .  X         . PLCFE
2000.- -Z- PY- - - - - - - - - -S - - - - - - - X- - - - - - PLCFE
     . Z   PY      .            S            .  X         . PLCFE
     . Z   PY      .            S            .  X         . PLCFE
     . Z   PY      .            S            .  X         . PLCFE
     . Z   PY      .            S            .  X         . PLCFE
     . Z   PY      .            S            .  X         . PLCFE
     . Z   PY      .            S            .  X         . PLCFE
     .Z    PY      .            S            . X          . PLCFE
     .Z    PY      .            S            . X          . PLCFE
     .Z    PY      .            S            . X          . PLCFE
2010.-Z- - PY- - - - - - - - - -S - - - - - - -X- - - - - - PLCFE
     .Z    PY      .            S            . X          . PLCFE
     .Z    PY      .            S            . X          . PLCFE
     .Z    PY      .            S            . X          . PLCFE
     .Z    PY      .            S            . X          . PLCFE
     .Z    PY      .            S            . X          . PLCFE
     .Z    PY      .            S            . X          . PLCFE
     .Z    PY      .            S            . X          . PLCFE
     .Z    PY      .            S            . X          . PLCFE
     .Z    PY      .            S            . X          . PLCFE
2020. Z- - PY- - - - - - - - - -S - - - - - - -X- - - - - - PLCFE
```

Fig. 13. Computer Run: Double Increase in External Funding.

PAGE 1   FILE SYSIN   DYNAMICS OF CHANGE IN SCHOOLS MODEL --A.K.GAYNOR

```
LOI=X,PPN=P,PLN=L,PCN=C,EF=F,LINK=Y,LE=E,CON=Z,SFI=S

           .0           3.75          7.5        11.25        15. X
           .0           25.           50.          75.        100. PLCFYEZ
       -100.           -50.           .0           50.        100. S
   1970.Z - -P- - - - - - - - - - - - S - - - -X- - - - - - - - - PLCFYE
         Z    P         .             S        X     .           . PLCFYE
         Z    P         .             S        X     .           . PLCFYE
         Z    P         .             S        X     .           . PLCFYE
         Z    P         .             S        X     .           . PLCFYE
         Z    P         .             S        X     .           . PLCFYE
         Z    PY        .             S        X     .           . PLCFE
         Z    PF   Y    .             S        X     .           . PLCE
         Z    P F       .Y            S        X     .           . PLCE
         Z    P    F    .       Y     S        X     .           . PLCE
   1980.Z - -PE - - -F- - - - - - - - SY- - - - X - - - - - - - - PLC
        .Z    PE        .   F      Y  S          X   .           . PLC
        .Z    P E       .    FY       S            X             . PLC
        . Z   P E       .   F         S          .   X           . PLC,FY
        . Z   P E       . YF          S          .     X         . PLC
        . Z   P E       .YF           S.         .       X       . PLC
        .  Z P   E     F              S.         .         X     . PLC,FY
        .  Z P   E    F.              S.         .          X    . PLC,FY
        .  Z-PL  E   F .              S.         .           X   . PC,FY
        .   ZPL  E FY  .              S.         .            X  . PC
   1990.- - ZPL  E F - - - - - - - - -S- - - - - - - - - - - -X- - PC,FY
        .   ZPL  EFY   .              S.         .             X . PC
        .   ZCP  EFY   .              S.         .             X . PL
        .   ZCP  F  Y  .             S .         .             X . PL,FE
        .    CP  F  Y  .             S .         .             X . PL,FE,CZ
        .    CP  FY    .             S .         .             X . PL,FE,CZ
        .    CP  FY    .              S.         .             X . PL,FE,CZ
        .    CP  FY    .              S.         .            X  . PL,FE,CZ
        .    CP  FY    .              S.         .            X  . PL,FE,CZ
        .    CP  FY    .              S.         .            X  . PL,FE,CZ
   2000.- - -ZP  FY- - - - - - - - - -S- - - - - - - - - - - -X- - PLC,FE
        .    ZP  FY    .              S.         .            X  . PLC,FE
        .   Z P  FY    .              S.         .            X  . PLC,FE
        .   Z P  FY    .              S.         .            X  . PLC,FE
        .   Z P  FY    .              S.         .            X  . PLC,FE
        .   Z LPFY     .              S.         .            X  . LC,FE
        .   Z LPFY     .              S.         .            X  . LC,FE
        .   Z LPFY     .              S.         .            X  . LC,FE
        .   Z LPFY     .              S.         .            X  . LC,FE
        .   Z LPFY     .              S.         .            X  . LC,FE
   2010.- -Z- LPFY- - - - - - - - - - S- - - - - - - - - - - -X- - LC,FE
        .  Z  LPFY     .              S.         .            X  . LC,FE
        .  Z  LPFY     .              S.         .            X  . LC,FE
        .  Z  LPFY     .              S.         .            X  . LC,FE
        .  Z  LPFY     .              S.         .            X  . LC,FE
        .  Z  LPFY     .              S.         .             X . LC,FE
        .  Z  LPFY     .              S.         .             X . LC,FE
        .  Z  LPFY     .              S.         .             X . LC,FE
        .  Z  LPFY     .              S.         .             X . LC,FE
        .  Z  LPFY     .              S.         .             X . LC,FE
   2020.- -Z- LPFY- - - - - - - - - -S- - - - - - - - - - - - - X - LC,FE
```

Fig. 14. Computer Run: Increase in External Linkage

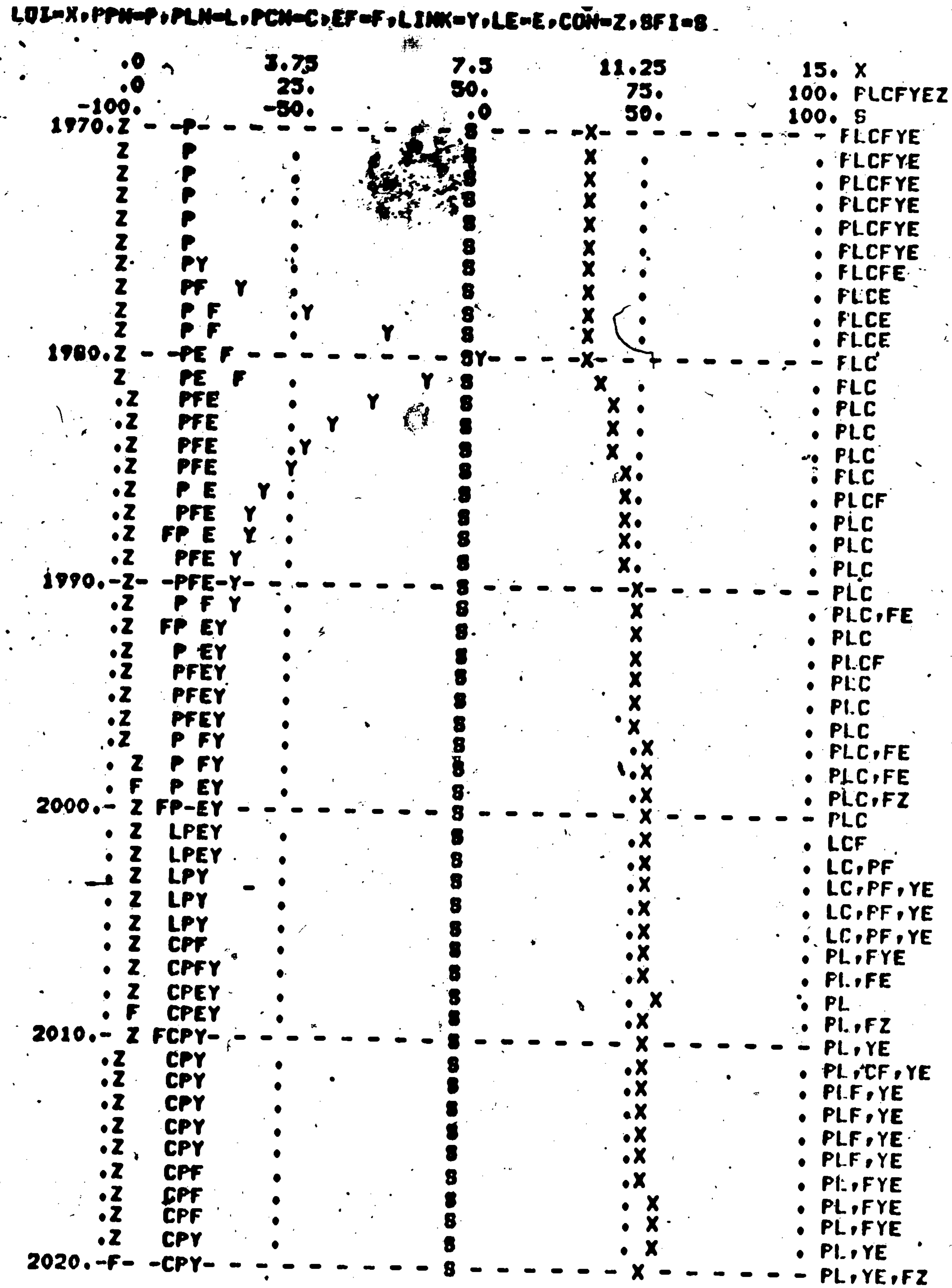

Fig. 15. Computer Run: Increase in External Linkage with Suppression of Internally Generated Increases in External Funding.

A brief might be made by some who would criticize the model that the positive effects of policies to increase external linkage are artificially enhanced by the theoretical connections in the model between linkage and funding. The assumption was made in constructing the model that persons with external professional connections in school systems are more likely to attract external funds to the school district than are persons without such connections. The logic underlying this assumption is based upon the personal experience that linked professionals are more likely to generate fundable ideas and proposals, more likely to be able to acquire the necessary technical competence to innovate successfully, and more likely to have the personal reputation which is often helpful in obtaining external funds. The logic expressed here also seems strongly consistent with the empirical literature in support of the relationship between cosmopolitanism and innovativeness (Carlson, 1965).

The assumption of the positive effects of external linkage upon external funding seems soundly descriptive of the dynamics of the real world of public schools. However, to take a perhaps unnecessarily conservative stance, a second test of the effects of external linkage was made (Fig. 15). In this test, increases in funding were artificially constrained (probably in violation of the physics of the real world) so that the effects of policies to increase external linkage could be examined assuming very little structural impact of linkage upon funding.

In this test the long-term effects of the short-run exogenous increase in external linkage (1975-1980) is mitigated by the change in the model structure. The positive impact of linkage on innovation is not eliminated, however, adding confidence to the prior conclusion.

Effects of Leadership Effectiveness and Tests of Dramatic vs. Incremental Change Strategies

It has long been believed that leadership effectiveness is a critical ingredient in organizations and that variations in leadership effectiveness impact significantly upon the success or failure of attempts to implement innovative practices. The literature on leadership is extensive (Gibb, 1965; Stogdill, 1948; Stogdill, 1974).

Belief in the saliency of leadership in organizations undergirds widespread investment in leader preparation programs in business, education, and the military as well as policy thrusts by agencies such as the Office of Edu-

cation (Education Professions Development Act) and the American Association of School Administrators (National Academy for School Executives).

Leadership effectiveness in the model is defined in value-neutral terms. It represents technical skills in planning, organizing, supervising, delegating, co-ordinating, etc. (Gulick and Urwick, 1937). The educational values of leaders (i.e., leader norms) constitute a separate element of the model.

It is, of course, assumed that effective leaders are more effective in the service of their own values. This assumption is built into the model.

The model also reflects an assumption that more effective leadership tends to be better linked externally and, implicitly if not conscientiously, has the effect of enhancing external linkage in the school system more generally. This is a significant, if debatable, assumption and implies that effective leadership can set in motion dynamics that transcend leaders, themselves. This constitutes a further reiteration of the key assumption that leadership is a property not simply of individuals but of the system itself.

The test of the effects of leadership effectiveness upon the school system not only affirmed the systemic salience of leadership but also raised another important issue. Because dramatic increases in leadership effectiveness had such a powerful and enduring impact upon the school system, a series of tests were run to examine the effects of sequentially diminished exogenous increases in leadership effectiveness (E) on the behavior of the system over time. The results, displayed in Figures 16-18, seem compelling with respect to the issue of dramatic vs. incremental policies of innovation.

Figure 16 shows the effects of a sharp increase in leadership effectiveness upon the school system. This input is exogenous for a ten-year period (1975-1985).

The impact upon the school system is dramatic. What is produced is a high degree of system instability, which is displayed across an array of indicators. Most significantly, the level of innovation (X) rises sharply but then falls, again, and continues to oscillate strongly during the entire run. Similar patterns of behavior are observed with respect to political support for innovation (S), and, especially, with respect to conflict (Z), which reaches very high levels around 1990 and, again, around 2010. It seems accurate to characterize this system

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PAGE 1   FILE SYSIN   DYNAMICS OF CHANGE IN SCHOOLS MODEL --A.K.GAYNOR

LOI=X,PPN=P,PLN=L,PCN=C,EF=F,LINK=Y,LE=E,CON=Z,SFI=S

        .0          6.25         12.5         18.75          25. X
        .0           25.          50.           75.         100. PLCFYEZ
     -100.          -50.           .0           50.         100. S
   1970.Z - -P- - - - - - - - -X- - S - - - - - - - - - - - - - PLCFYE
        Z    P       .       X    S            .             . PLCFYE
        Z    P       .       X    S            .             . PLCFYE
        Z    P       .       X    S            .             . PLCFYE
        Z    P       .       X    S            .             . PLCFYE
        Z    P       .       X    S            .             . PLCFYE
        Z    PE      .       X    S            .             . PLCFY
        Z    PY   E  .       X    S            .             . PLCF
        Z    PFY     .  E     X   S            .             . PLC
        .Z   P FY    .        XE S             .             . PLC
   1980.-Z- -P- -FY - - - - - - -XS - - - E - - - - - - - - - - PLC
        . Z  P     F .          S.X            . E           . PLC,FY
        . Z  P      FY          S.   X         .    E        . PLC
        .  Z P       .F     .  S .      X      .       E     . PLC,FY
        .   ZCP      .FY      S  .         X   .        E    . PL
        .    CP      . FY   S    .            X.         E.  PL,CZ
        .    CP  Z   . FYS       .             . X      E    . PL
        .    CP      . F Y       .             .   X   E     . PL,YZ,FS
        .    CLP    S F Y   Z    .             .    X  E     .
        .    C P   S. F  Y    Z.               .   X E       . PL
   1990.- - -C-P- - S F - Y - - - Z - - - - - X - -E- - - - - - PL
        .     CLP    .F   Y       Z       X    . E           . FS
        .     CLP    .F SY        Z  X         .E            .
        .     CLP    F   Y S  Z  X.           E.             .
        .     CLP    F   Y    S  X.          E .             . YZ
        .     LP   ZF.   Y     SX .         E  .             . LC
        .     LPZ   F.   Y      SX.         E  .             . LC
        .    ZLP    F. Y         SX        E   .             . LC
        .   Z LP    F. Y         S.  X     E   .             . LC
        .  Z  P     F. Y         S.    X  E    .             . PLC
   2000.- Z - P - - F - Y - - - -S- - - -XE - - - - - - - - - - PLC
        . Z   P     F.  Y       S .       E X  .             . PLC
        .  Z  P     F.  Y      S  .       E   X.             . PLC
        .   Z CP     F    Y  S    .      E     .X            . PL
        .     CP     F    Y S     .      E     .   X         . PLZ
        .     CP   Z .F   Y       .      E     .     X       . PL,YS
        .     CP     .FS   YZ     .     E      .      X      . PL
        .     CLP    .F    Y    Z .     E      .      X      . FS
        .     CLP    SF    Y      .Z   E       .   X         .
        .     C P    .F    Y      .ZE         X.             . PL,FS
   2010.- - - C P - - F S Y - - - -EZ - X - - - - - - - - - - - PL
        .     C P    F   Y S   Z  EX           .             . PL
        .      LP    F   Y Z  S  XE            .             . LC
        .      LP   FZ   Y    S X.             .             . LC,XE
        .      LPZ  F. Y         EX            .             . LC,ES
        .     ZLP   F. Y         E.X           .             . LC,ES
        .   Z  P   F . Y        E S   X        .             . PLC
        .  Z,  P   F . Y        E S      X     .             . PLC
        . Z    P   F . Y        ES.        X   .             . PLC
        . Z    P    F. Y        ES.          X .             . PLC
   2020.- Z - -P- - F -Y- - - - E - - - - - - - -X- - - - - - - PLC,ES
```

Fig. 16. Computer Run: Strong Increase in Leadership Effectiveness.

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PAGE 1   FILE SYSIN   DYNAMICS OF CHANGE IN SCHOOLS MODEL --A.K.GAYNOR

LOI=X,PPN=P,PLN=L,PCN=C,EF=F,LINK=Y,LE=E,CON=Z,SFI=S

          .0          6.25          12.5         18.75          25. X
          .0          25.           50.           75.          100. PLCFYEZ
      -100.          -50.            .0           50.          100. S
   1970.Z - -P- - - - - - - - - -X- - S - - - - - - - - - - - - - - PLCFYE
        Z     P          .        X    S             .             . PLCFYE
        Z     P          .        X    S             .             . PLCFYE
        Z     P          .        X    S             .             . PLCFYE
        Z     P          .        X    S             .             . PLCFYE
        Z     P          .        X    S             .             . PLCFYE
        Z     P          .        X    S             .             . PLCFYE
        Z     PE         .        X    S             .             . PLCFY
        Z     PYE        .        X    S             .             . PLCF
        Z     PF   E     .        X    S             .             . PLC,FY
   1980.Z - -PFY- -E- - - - - - - X - S - - - - - - - - - - - - - - PLC
        Z     P FY       E          X  S             .             . PLC
        .Z    P   FY     .     E      X S            .             . PLC
        .Z    P     F    .        E    X             .             . PLC,FY,XS
        . Z   P      F   .            E. X           .             . PLC,FY,ES
        . Z   P       F.              S.  E X        .             . PLC,FY
        .   Z CP        FY           S . E      X    .             . PL
        .    ZCP        .FY        S   . E        X  .             . PL
        .     CP        .FY      S     . E           X             . PLZ
        .     CP     Z  .F Y S         .E            .  X          . PL
   1990.- - -CLP- - - F ZY- - - - -E- - - - - - - - - - X - - - - - ZS
        .     CLP       .F   Y      Z  E             .   X         . FS
        .     C P       SF   Y         EZ            .  X          . PL
        .      CLP      SF   Y        E. Z          X.             .
        .      CLP      .FS Y       E  . Z    X      .             .
        .      CLP     F    YS     E   X Z           .             .
        .      CLP     F.    Y    S X  .             .             . XEZ
        .      CLP     F. Y Z.    XS   .             .             . XE
        .      LP     FZ.Y        X  S .             .             . LC,XE
        .      LPZ   F  .Y        EX  S.             .             . LC
   2000.- - - LP- F -Y- - - - E - X S - - - - - - - - - - - - - - - LCZ
        .    Z P     F   Y        E     X            .             . PLC,XS
        . Z    P     F   Y .      E     S X          .             . PLC
        . Z    P     F   Y        E     S  X         .             . PLC
        . Z    P     F   Y        E    S.    X       .             . PLC
        . Z    P      F  Y        E    S.      X     .             . PLC
        . Z    P      F .Y       E    S .         X  .             . PLC
        .   Z  P      F .Y       E  S   .            X             . PLC
        .     ZCP     F .Y       E S    .            . X           . PL
        .      CPZ    F . Y      E      .            .   X         . PL,ES
   2010.- - - CP- - F -Y-S-E- - - - - - - - - - - - - - - X - - - - PL,FZ
        .      CLP     F. YS ZE         .            .      X      .
        .      CLP     F. Y  E        Z.             .      X      . YS
        .      CLP     F. Y  E          .  Z         .  X          . YS
        .      C P     F. YSE           .   Z     X  .             . PL
        .      C P     F. YE S          . ZX         .             . PL
        .      CLP    F .YE      S    ZX .           .             .
        .       LP    F Y E     Z   X   .            .             . LC,XS
        .       LP F  YZE           X S .            .             . LC
        .       LP F Y. E            X S.            .             . LC,FZ
   2020.- - - -P-F- Y -E- - - - - X S - - - - - - - - - - - - - - - PLCZ
```

Fig. 17. Computer Run: Moderate Increase in Leadership Effectiveness.

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PAGE 1    FILE SYSIN   DYNAMICS OF CHANGE IN SCHOOLS MODEL --A.K.GAYNOR

LOI=X,PPN=P,PLN=L,PCN=C,EF=F,LINK=Y,LE=E,CON=Z,SFI=S

        .0        6.25         12.5        18.75        25. X
        .0         25.         50.          75.        100. PLCFYEZ
     -100.        -50.          .0          50.        100. S
   1970.Z - -P- - - - - - - -X- - S - - - - - - - - - - - - PLCFYE
        Z    P       .      X    S            .           . PLCFYE
        Z    P       .      X    S            .           . PLCFYE
        Z    P       .      X    S            .           . PLCFYE
        Z    P       .      X    S            .           . PLCFYE
        Z    P       .      X    S            .           . PLCFYE
        Z    P       .      X    S            .           . PLCFYE
        Z    P       .      X    S            .           . PLCFYE
        Z    PE      .      X    S            .           . PLCFY
        Z    PE      .      X    S            .           . PLCFY
   1980.Z - -PY - - - - - -X- - S - - - - - - - - - - - - - PLCF,YE
        Z    PYE     .      X    S            .           . PLCF
        Z    PF E    .      X    S            .           . PLC,FY
        Z    PF E    .       X   S            .           . PLC,FY
        Z    PFY E   .       X   S            .           . PLC
        .Z   P F  E  .       X   S            .           . PLC,FY
        .Z   P FY E  .        X  S            .           . PLC
        .Z   P  F E  .         X S            .           . PLC,FY
        .Z   P  FYE  .         X S            .           . PLC
        .Z   P  FYE  .          XS            .           . PLC
   1990.- Z -P- -FE - - - - - - -SX - - - - - - - - - - - - PLC,FY
        . Z  LP  FY  .          SX            .           . LC,YE
        . Z  LP  FY  .          S.X           .           . LC,YE
        . Z  CP  FY  .          S. X          .           . PL,YE
        .  Z CP  FY  .          S. X          .           . PL,YE
        .  Z CP  FY  .          S.  X         .           . PL,YE
        .  Z CP  FY  .          S.   X        .           . PL,YE
        .  Z CP  FY  .          S.   X        .           . PL,YE
        .  Z CP  F Y .          S.    X       .           . PL,FE
        .   ZCP  F Y .          S.    X       .           . PL,FE
   2000.- - ZCP -F-Y- - - - - -S - - - X - - - - - - - - - - PL,FE
        .   ZCLP F Y .         S .     X      .           . FE
        .    CLP F Y .         S .     X      .           . FE,CZ
        .    ZLP F Y .         S .      X     .           . LC,FE
        .    ZLP F Y .         S .      X     .           . LC,FE
        .     LP F Y .         S .      X     .           . LCZ,FE
        .     LP F Y .        S  .      X     .           . LCZ,FE
        .     LP F Y .        S  .      X     .           . LCZ,FE
        .     LP F Y .        S  .      X     .           . LC,FE,PZ
        .     LP F Y .        S  .      X     .           . LC,FE,PZ
   2010.- - - LP-F-Y- - - - - -S- - - - -X- - - - - - - - - - LC,FE,PZ
        .     CP F Y .        S  .      X     .           . PLZ,FE
        .     CP F Y .        S  .      X     .           . PLZ,FE
        .     CP F Y .         S .      X     .           . PLZ,FE
        .     CP F Y .         S .      X     .           . PLZ,FE
        .     CP F Y .         S .      X     .           . PLZ,FE
        .     CP F Y .         S .      X     .           . PLZ,FE
        .     CP F Y .         S .      X     .           . PLZ,FE
        .     CP F Y .         S .      X     .           . PL,FE,CZ
        .     CP F Y .         S .      X     .           . PL,FE,CZ
   2020.- - - CP-F-Y- - - - - - S - - - -X- - - - - - - - - - PL,FE,CZ
```

Fig. 18. Computer Run: Gradual Increase in Leadership Effectiveness.

as unstable and in a state of conflict.

Figure 17 shows the effects of an increase in leadership effectiveness over a ten-year period (1975-1985) but of an intensity only 20% as strong as that in the previous run. The results, however, are hardly distinguishable from those shown in Figure 16.

Figure 18 also shows the effects of an increase in leadership effectiveness over a ten-year period (1975-1985). In this run, however, the intensity of the increase has been reduced by another factor of five to 4% of the initial magnitude. Now the results are markedly different.

In this run, the dramatic oscillations are gone. Political support for innovation (S) goes only moderately negative and begins to return to the neutral point toward the end of the run. Conflict levels (Z) rise throughout the run but remain within the functional range. The level of innovation (X) rises slowly but persistently throughout the run, along with the relevant norms (P, L and C) which lag but rise gradually behind the level of innovation.

Several conclusions emerge tentatively from this series of tests. First, it appears that leadership effectiveness is, indeed, a powerful factor in the life of the public school system, with potentially dramatic effects, not all of them necessarily desirable. Second, it appears that when a deeply integrated element, such as leadership effectiveness, becomes the object of policy intervention, the effects may be largely counterintuitive. Third, it seems that the issue of dramatic vs. incremental change strategies is a significant issue and that the long-term effects of incrementalism may, in fact, be superior.*

<u>Effects of Forced Implementation and Further Tests of Dramatic vs. Incremental Change Strategies</u>

The last policy intervention to be examined was of

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* Of course a question which may be raised is that which focuses upon the meaning of incrementalism. Incrementalism implies a gradual approach to change. How gradual? The answer to the question is crucial, especially for the practitioner. The answer seems to be, "Gradual enough so that conflict levels do not get beyond the functional range." (c.f., Figs. 7 and 8 Supra, pp. 17 and 18.)

the type which has been spotlighted in some of the court-ordered racial desegregation cases. The conclusions from model-testing may be relevant, for example, in assessing some of the likely long-term effects of Judge W. Arthur Garrity's decision in Boston.

The test was to increase exogenously the rate of implementation of an innovation (e.g., racial desegregation) in public schools. In performing this test, a critical assumption was made, one which may or may not be supportable in real world politics. It is the assumption that implementation can be mandated from the outside and that the mandating agency is, itself, beyond the political reach of forces internal to the public school system. For the test to represent a valid analogy, this assumption must be true, at least for the time frame of the mandate, itself (in contradistinction to the time frame of the entire test run).

This series of tests is similar to the previous one in that an attempt was made to examine not only the impact of the direct mandate, itself, but also the relative effects of dramatic vs. incremental change strategies on the part of the mandating agency. The results of these tests are displayed in Figures 19-21.

In the initial test run (Fig. 19), a sharp, mandated increase in implementation is exogenously inputted over a five-year period (1975-80). The result is a period of approximately twenty years (1975-1995) during which there is substantial system instability. This period is marked by an initial rise in innovation (X), external funding (F), and external linkage (Y), all of which fall back toward initial levels over time. Initial gains in innovation are followed shortly by declining levels of political support for innovation (S) and dramatic increases in the level of conflict (Z). The level of innovation falls below initial levels in the fifteen years following the withdrawal of the external mandate (1980-1995) and begins to rise gradually above the initial level only after the school system restabilizes many years later (2000-2020).

In the second test run (Fig. 20), the mandated increase in implementation is diminished by a factor of five, to only 20% of the initial rate, but stretched over a ten year period (1975-1985). In this run, there is less conflict (Z) and less oscillation in political support levels (S), but the pattern of instability is similar, if less intense.

In the final test run (Fig. 21), the mandated increase is diminished by an additional factor of two to only 10%

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PAGE 1   FILE SYSIN   DYNAMICS OF CHANGE IN SCHOOLS MODEL --A.K.GAYNOR

LOI=X,PPN=P,PLN=L,PCN=C,EF=F,LINK=Y,LE=E,CON=Z,SFI=S

           .0         6.25        12.5        18.75         25. X
           .0          25.          50,          75.         100. PLCFYEZ
        -100.         -50.          .0          50.         100. S
      1970.Z - -P- - - - - - - -X- - S - - - - - - - - - - - - - PLCFYE
           Z    P       .       X    S            .            . PLCFYE
           Z    P       .       X    S            .            . PLCFYE
           Z    P       .       X    S            .            . PLCFYE
           Z    P       .       X    S            .            . PLCFYE
           Z    P       .       X    S            .            . PLCFYE
           Z    PF      .        X   S            .            . PLCYE
           .Z   PY  F   .          X S            .            . PLCE
           . Z  P  Y    F            S   X        .            . PLCE
           .   ZP   Y   .   F       S.          X .            . PLCE
      1980.- - -CP - -Y- - - -F- -S- - - - - - - - - - - X - - - PLZ,CE
           .    CP  Z Y .   F  S     .            .     X      . PL,CE
           .    CP    Y .F   S       .            .   X        . PL,CE,FZ
           .    CLP   YF.  S     Z   .            .X           . LE
           .    C P  YF .  S         .    Z X     .            . PL,CE
           .    C P YF  .    SX      .       Z    .            . PL,CE
           .    CLXF    .       S    .     Z      .            . XP,FY,CE
           .   XELPY    .           S.Z           .            . LC,PF
           .  XE LP     .         Z  .  S         .            . LCF,PY
           .  XELPY     .     Z      .     S      .            . PC,LF
      1990.- - XLP - - - - Z - - - - - - - - S - - - - - - - - - PCY,XFE
           .   XPC      Z            .        S   .            . PLE,XF,CY
           .   FXY    Z .            .        S   .            . XPLCE
           .   PLYX Z   .            .        S   .            . LCE,PF
           .   PLY X    .            .       S    .            . LCE,PF,XZ
           .   PCY  X   .            .       S    .            . PLF,CE,YZ
           .   PC    X  .            .     S      .            . PLF,CYEZ
           .  PLC      X.            .    S       .            . LF,CYEZ
           .  PLC       X            .   S        .            . LFZ,CYE
           .  PLC       .X           .  S         .            . LF,CYE,PZ
      2000.- -ZPL- - - - -X- - - - - - -S- - - - - - - - - - - - LCYE,PF
           . Z PL       .  X         . S          .            . LCYE,PF
           . Z PL       .  X         .S           .            . LCFYE
           . Z PL       .   X        .S           .            . LCFYE
           .Z  PL       .   X        .S           .            . LCFYE
           .Z  PL       .    X       .S           .            . LCFYE
           .Z  PL       .    X       S            .            . LCFYE
           .Z  PL       .    X       S            .            . LCFYE
           .Z  PL       .    X       S            .            . LCFYE
           Z   PL       .     X      S            .            . LCFYE
      2010.Z - PL- - - - - - -X- - - S - - - - - - - - - - - - - LCFYE
           Z    P       .     X      S            .            . PLCFYE
           Z    P       .     X      S            .            . PLCFYE
           Z    P       .     X      S            .            . PLCFYE
           Z    P       .     X      S            .            . PLCFYE
           Z    P       .     X      S            .            . PLCFYE
           Z    P       .     X      S            .            . PLCFYE
           Z    P       .     X      S            .            . PLCFYE
           Z    P       .     X      S            .            . PLCFYE
           Z    P       .     X      S            .            . PLCFYE
      2020.Z - -P- - - - - - -X- - - S - - - - - - - - - - - - - PLCFYE
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Fig. 19. Computer Run: Strong Mandated Increase in Implementation.

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PAGE 1   FILE SYSIN   DYNAMICS OF CHANGE IN SCHOOLS MODEL --A.K.GAYNOR

LOI=X,PPN=P,PLN=L,PCN=C,EF=F,LINK=Y,LE=E,CON=Z,SFI=S

     .0          6.25         12.5         18.75          25. X
     .0           25.          50.           75.         100. PLCFYEZ
  -100.          -50.           .0           50.         100. S
1970.Z - -P- - - - - - - - -X- - S - - - - - - - - - - - - - - PLCFYE
     Z    P       .       X    S            .            . PLCFYE
     Z    P       .       X    S            .            . PLCFYE
     Z    P       .       X    S            .            . PLCFYE
     Z    P       .       X    S            .            . PLCFYE
     Z    P       .       X    S            .            . PLCFYE
     Z    P       .       X    S            .            . PLCFYE
     Z    PF      .        X   S            .            . PLCYE
     .Z   PYF     .         X  S            .            . PLCE
     .Z   PY F    .          X S            .            . PLCE
1980.- Z -P-Y- F - - - - - - - X - - - - - - - - - - - - - - - PLCE,XS
     .  Z P Y    F .         S.  X          .            . PLCE
     .  Z P  Y   F .         S.     X       .            . PLCE
     .   ZCP Y    F.         S.        X    .            . PL,CE
     .    CP  Y   F.       S  .           X .            . PLZ,CE
     .    CP ZY   F.      S   .             .X           . PL,CE
     .    CP  YZF .     S     .            X.            . PL,CE
     .    CLP YF  .Z    S     .          X  .            . CE
     .    CLP F   .    ZS     .        X    .            . FY,CE
     .    CLPFY   .     SZ    .   X         .            . CE
1990.- - -CLPF - - - - - -Z- -X- - - - - - - - - - - - - - - - FY,CE,ZS
     .    ELPY    .     ZX S  .             .            . LC,PF
     .    ELP     .   XZ   S  .             .            . LC,PFY
     .    ELP     . ZX      S.              .            . LCF,PY
     .    ELP     .Z X       S              .            . LCFY
     .    EF     Z. X        .S             .            . PLCFY
     .    EF   Z  . X        .S             .            . PLCY,FE
     .    LPZ     . X        .S             .            . PCY,LFE
     .    PE      . X        .S             .            . PLFE,CYZ
     .    PC      .  X       .S             .            . PLFEZ,CY
2000.- -Z-PC - - - - X - - - - S- - - - - - - - - - - - - - - - PLFE,CY
     .   Z PC     .  X       .S             .            . PLFYE
     .   Z PC     .   X      .S             .            . PLFYE
     .  Z  PC     .   X      .S             .            . PLFYE
     .  Z  PC     .   X      .S             .            . PLFYE
     .Z    PC     .    X     .S             .            . PLFYE
     .Z    P      .    X     .S             .            . PLCFYE
     .Z    P      .    X     .S             .            . PLCFYE
     .Z    P      .     X    .S             .            . PLCFYE
     .Z    P      .     X    S              .            . PLCFYE
2010.Z - -P- - - - - - - - -X- - - S - - - - - - - - - - - - - PLCFYE
     Z     P      .     X    S              .            . PLCFYE
     Z     P      .     X    S              .            . PLCFYE
     Z     P      .     X    S              .            . PLCFYE
     Z     P      .     X    S              .            . PLCFYE
     Z     P      .      X   S              .            . PLCFYE
     Z     P      .      X   S              .            . PLCFYE
     Z     P      .      X   S              .            . PLCFYE
     Z     P      .      X   S              .            . PLCFYE
     Z     P      .      X   S              .            . PLCFYE
2020.Z - -P- - - - - - - - X - - S - - - - - - - - - - - - - - PLCFYE
```

Fig. 20. Computer Run: Moderate Mandated Increase in Implementation.

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PAGE 1   FILE SYSIN   DYNAMICS OF CHANGE IN SCHOOLS MODEL --A.K.GAYNOR

LOI=X,PPN=P,PLN=L,PCN=C,EF=F,LINK=Y,LE=E,CON=Z,SFI=S

        .0            6.25          12.5          18.75          25. X
        .0            25.           50.            75.          100. PLCFYEZ
     -100.           -50.            .0            50.          100. S
  1970.Z - -P- - - - - - - - -X- - S - - - - - - - - - - - - - - - PLCFYE
       Z    P          .       X    S             .              . PLCFYE
       Z    P          .       X    S             .              . PLCFYE
       Z    P          .       X    S             .              . PLCFYE
       Z    P          .       X    S             .              . PLCFYE
       Z    P          .       X    S             .              . PLCFYE
       Z    P          .       X    S             .              . PLCFYE
       Z    PF         .       X    S             .              . PLCYE
       Z    PF         .        X   S             .              . PLCYE
       .Z   PYF        .        X   S             .              . PLCE
  1980.-Z- -PYF- - - - - - - - -X- S - - - - - - - - - - - - - - - PLCE
       . Z  PY F       .           XS             .              . PLCE
       . Z  PY  F      .            X             .              . PLCE,XS
       .  Z P Y F      .           S.X            .              . PLCE
       .  Z P Y F      .           S.   X         .              . PLCE
       .   ZCPY F      .           S.     X       .              . PL,CE
       .   ZCPY F      .           S.     X       .              . PL,CE
       .   ZCPYF       .          S .    X        .              . PL,CE
       .    CPF        .          S .    X        .              . PL,FY,CEZ
       .    CPF        .          S .   X         .              . PL,FY,CEZ
  1990.- - -CPF- - - - - - - - - -S - X - - - - - - - - - - - - - PL,FY,CEZ
       .    CPF        .           S. X           .              . PL,FY,CEZ
       .    CPF        .           S.X            .              . PL,FY,CEZ
       .    CPF        .           S.X            .              . PL,FY,CEZ
       .    CPY        .           SX             .              . PLF,CEZ
       .    CPY        .           SX             .              . PLFE,CZ
       .   ZCPY        .           SX             .              . PLFE
       .   Z PY        .           SX             .              . PLCFE
       .   Z PY        .           XS             .              . PLCFE
       .  Z  PY        .           XS             .              . PLCFE
  2000.- -Z- PY- - - - - - - - - -XS - - - - - - - - - - - - - - - PLCFE
       .  Z  P         .           XS             .              . PLCFYE
       . Z   P         .           XS             .              . PLCFYE
       . Z   P         .           XS             .              . PLCFYE
       . Z   P         .           XS             .              . PLCFYE
       . Z   P         .           XS             .              . PLCFYE
       . Z   P         .          X S             .              . PLCFYE
       .Z    P         .          X S             .              . PLCFYE
       .Z    P         .          X S             .              . PLCFYE
       .Z    P         .          X S             .              . PLCFYE
  2010.-Z- - P - - - - - - - - - -X S - - - - - - - - - - - - - - - PLCFYE
       .Z    P         .          X S             .              . PLCFYE
       .Z    P         .          X S             .              . PLCFYE
       .Z    P         .          X S             .              . PLCFYE
       .Z    P         .          X S             .              . PLCFYE
       .Z    P         .          X S             .              . PLCFYE
       .Z    P         .          X S             .              . PLCFYE
       .Z    P         .          X S             .              . PLCFYE
       .Z    P         .          X S             .              . PLCFYE
       .Z    P         .          X S             .              . PLCFYE
  2020.-Z- - P - - - - - - - - - -X S - - - - - - - - - - - - - - - PLCFYE
```

Fig. 21. Computer Run: Gradual Mandated Increase in Implementation.

of the initial rate.

The results of this run seem to reinforce conclusions drawn earlier with respect to dramatic vs incremental approaches to innovation. Dramatic attempts at externally mandated implementation of innovative practices seem to generate substantial levels of instability and conflict in the school system with modest gains in innovation at best. Incremental strategies seem to produce at least as many gains in the long-term without periods of conflict and instability.

DISCUSSION

The study was generated out of a concern for both substantive and methodological questions related to change theory and educational policy analysis. Examination of the literature on planned change (Gaynor, 1977 b) suggested that although considerable work had been done in describing many dimensions of educational change, there was still a need for a theoretical perspective which was essentially holistic.

It was also felt that, from a methodological perspective, there were needs to develop an alternative to multiple regression approaches to hypothesis testing, to explore an approach to holistic theory development, and to move toward the development of more precise techniques for examining educational policy issues.

It was the purpose of this study to describe a modest theory of educational change which could be stated with some precision, which could produce known historical behaviors, which would facilitate an understanding of the structural dynamics giving rise to those behaviors, and which would permit the examination of selected policies which have some historical currency.

This paper represents an attempt to describe for an audience of informed educators, not necessarily with substantial knowledge of system dynamics, work that has been done in the past year toward these ends and to make explicit the results of that work.

The experimental results seem to represent movement in the directions posited above in the description of the purpose of the study. It seems reasonable to assert that it is possible to explain the historical behavior of public schools with respect to innovation on the basis of a relatively small number of highly aggregated structural elements.

The fact that the model reproduces reasonable well the historical behavior reference modes certainly does not prove that the structural model is a valid one. No claim is made for that. It does seem to suggest, however, that the current theoretical formulation may be on the right track and, more importantly, that the method may be worth pursuing as understandings are sought about stability and change in public schools and about other issues of scientific consequence in the field of education.

The substantive findings are tentative but interesting. Policy runs do not suggest, for example, that external funding, alone, represents an effective strategy to bring about change in public schools. They do suggest that, consistent with current N.I.E. policy, external linkage (networking) is a more powerful long-term strategy. Study results also suggest that leadership effectiveness is, indeed, a critical element in organizational change but that dramatic attempts to alter current levels of leadership effectiveness may produce significant counter-intuitive effects in the form of conflict and system instability. In fact, a major conclusion one might draw from the work to date is that gradualism in the service of innovation has something to be said for it.

What has not been explored in the current work is a crucial meta-issue. What is the generality, universality, essential stability of the structure itself? To what extent might change strategies be aimed at altering this fundamental structure (i.e., the model, itself)? What superstructure holds that structure in place? Of course, these are the issues of which revolutionary philosophies are made. The order of that analysis is different from that which has informed the work of the past year. The method would not necessarily be different, but certainly the order is of a higher magnitude.

Clearly, there are important issues which remain to be resolved. The issue of the appropriate order of analysis is a crucial one. This is what systems analysts call the system boundary question. Other unresolved issues identified earlier have to do with the sticky concepts of leadership and limits.

To the extent that an analytic method forces the identification of significant meta-issues, it seems like a useful method. It seems reasonable to believe, at this point, that the system dynamics method provides a provocative perspective, a potentially useful analytic method, and an encouraging alternative to traditional linear perspectives and statistical analytic techniques. The method

seems particularly well adapted to theory development, and because of its precise problem orientation, to policy analysis.

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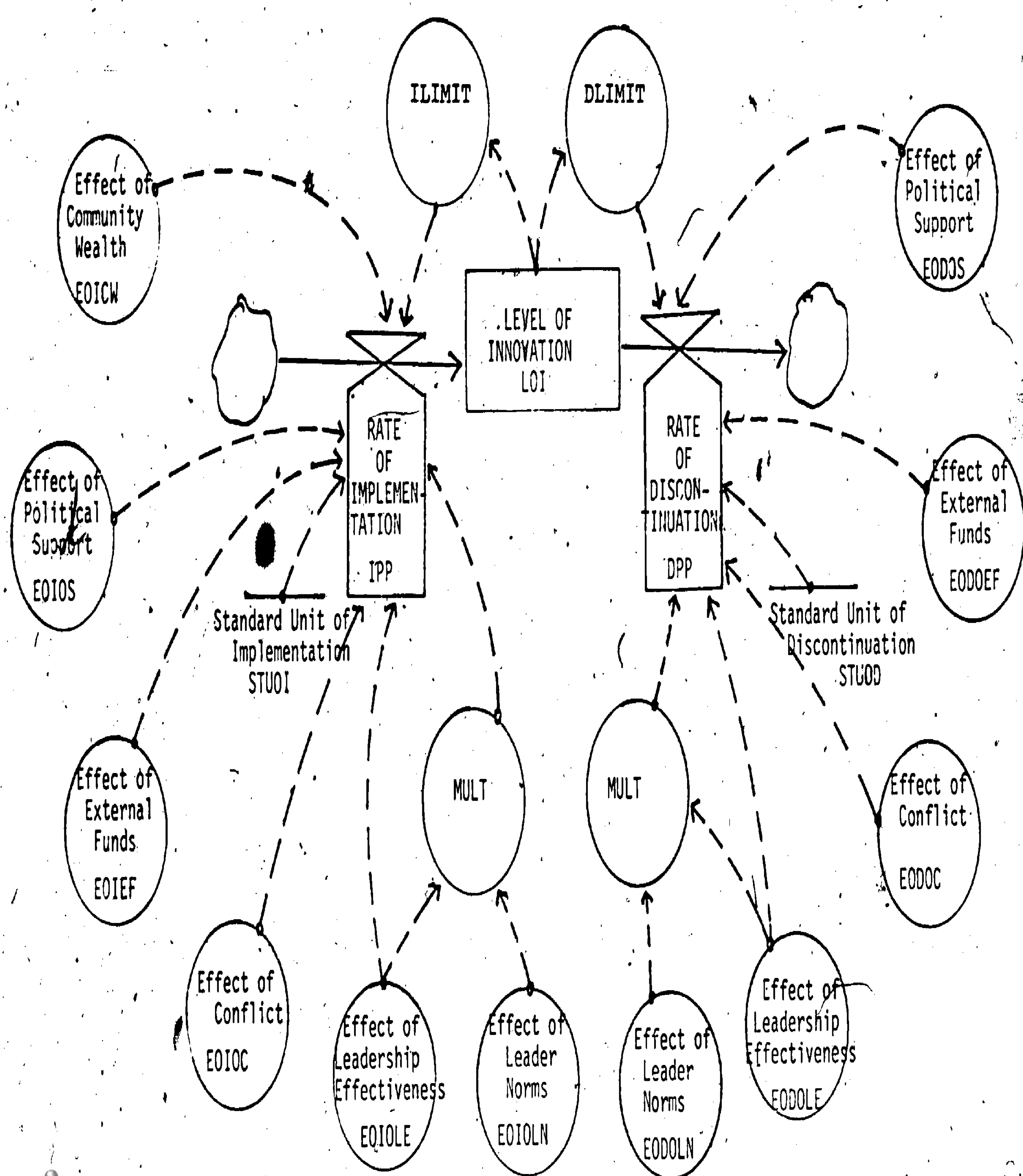
APPENDIX A

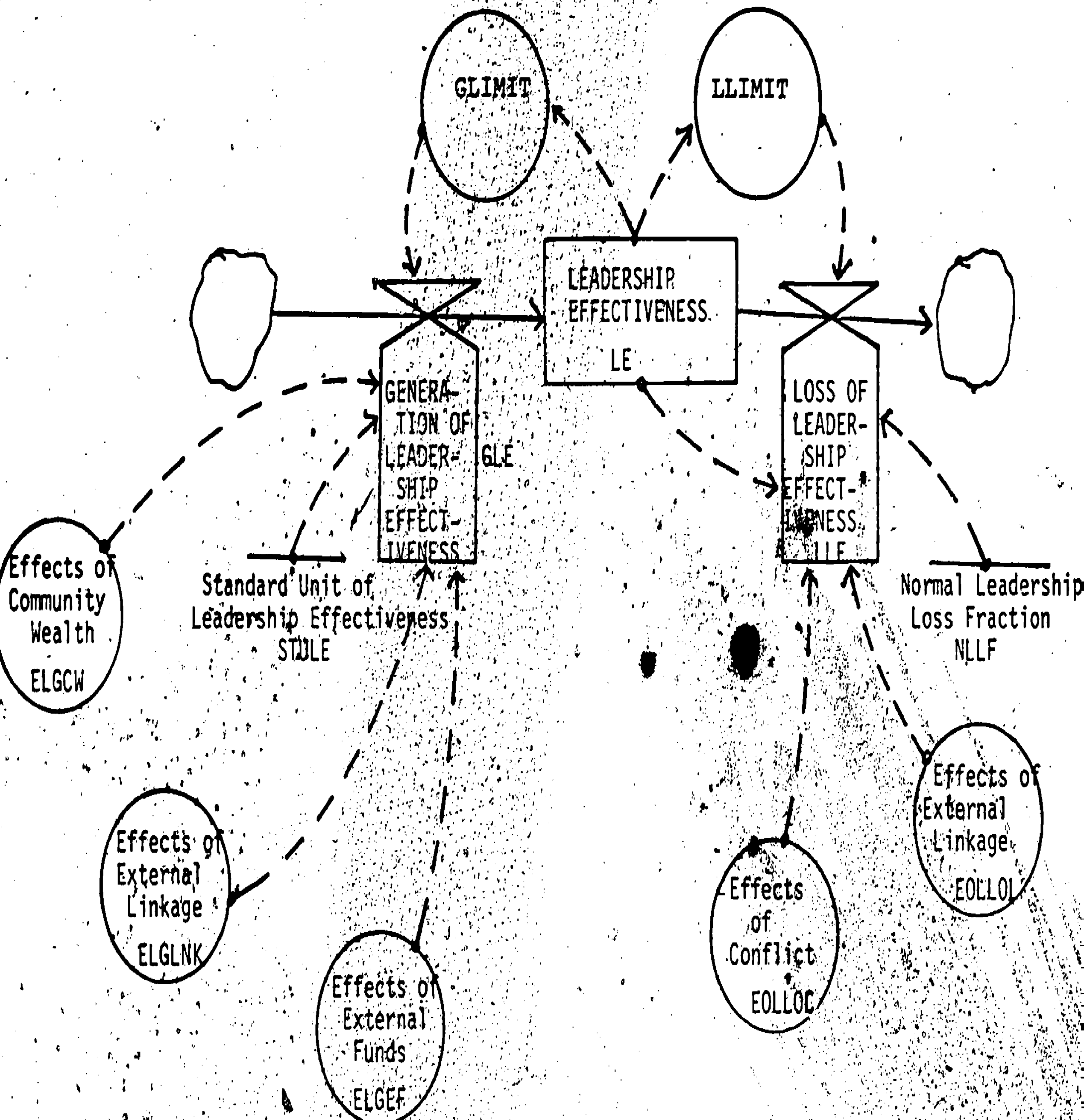
Model Flow Diagrams

IMPLEMENTATION AND INNOVATION SECTOR

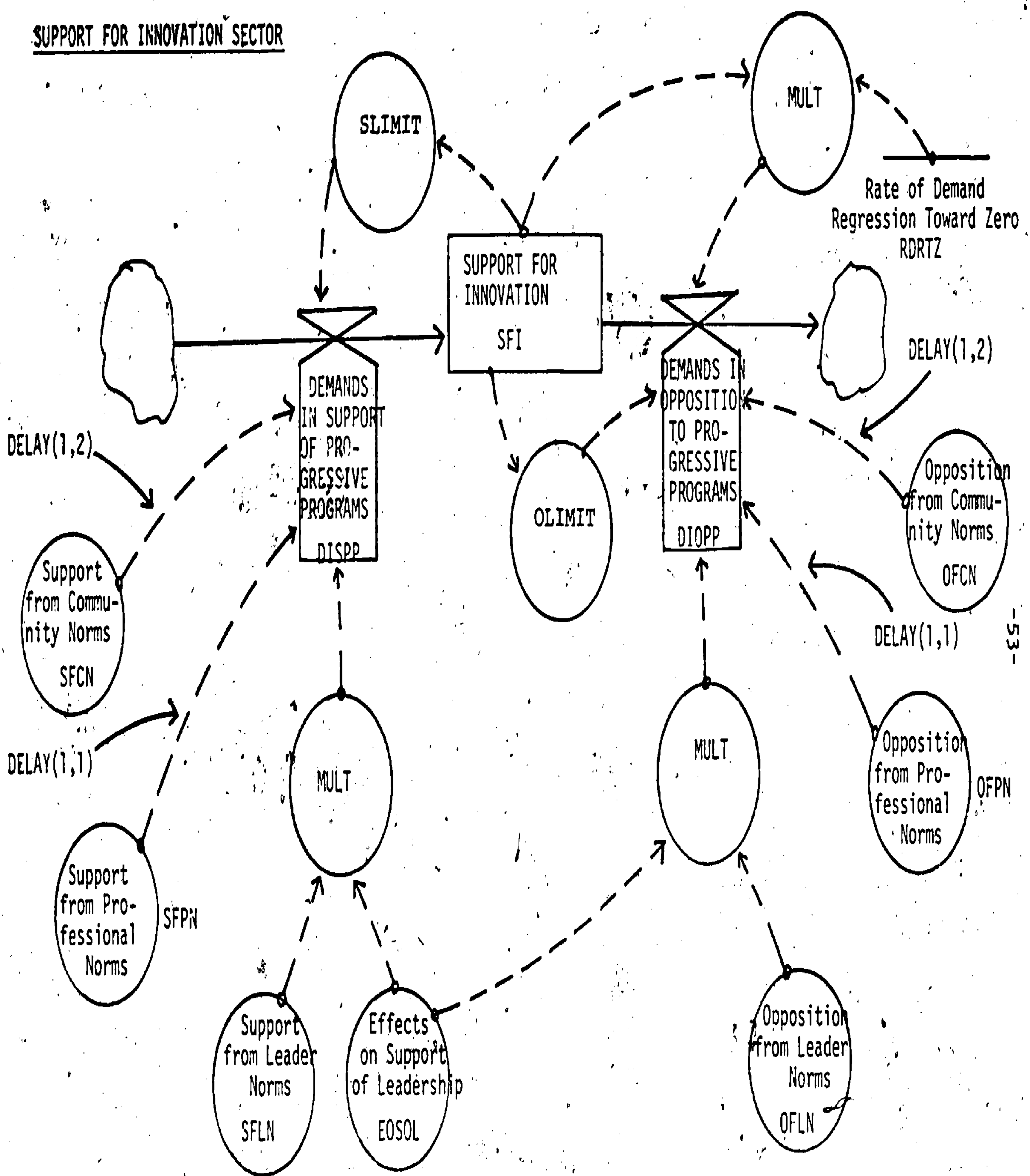


-51-

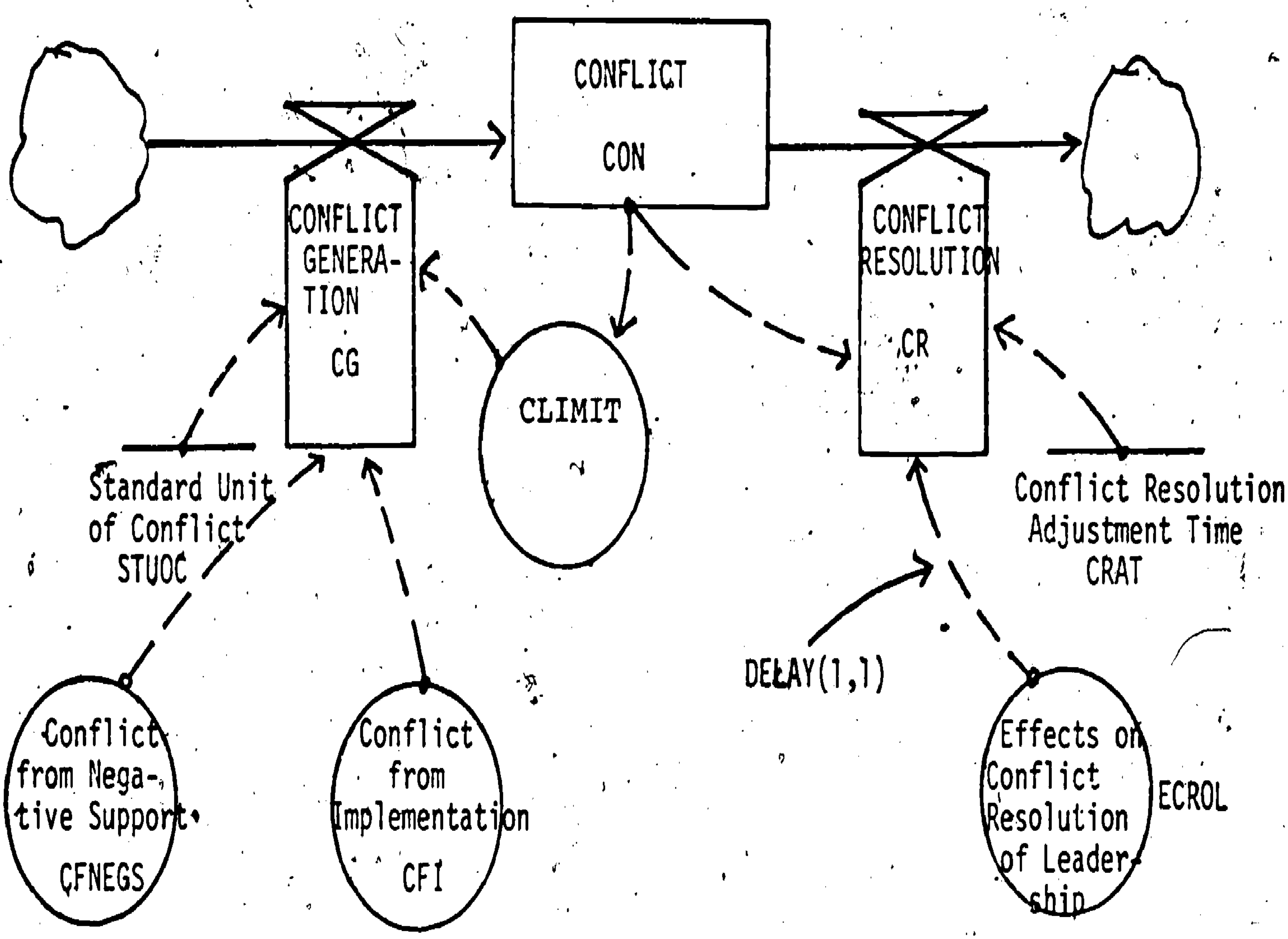
LEADERSHIP EFFECTIVENESS SECTOR



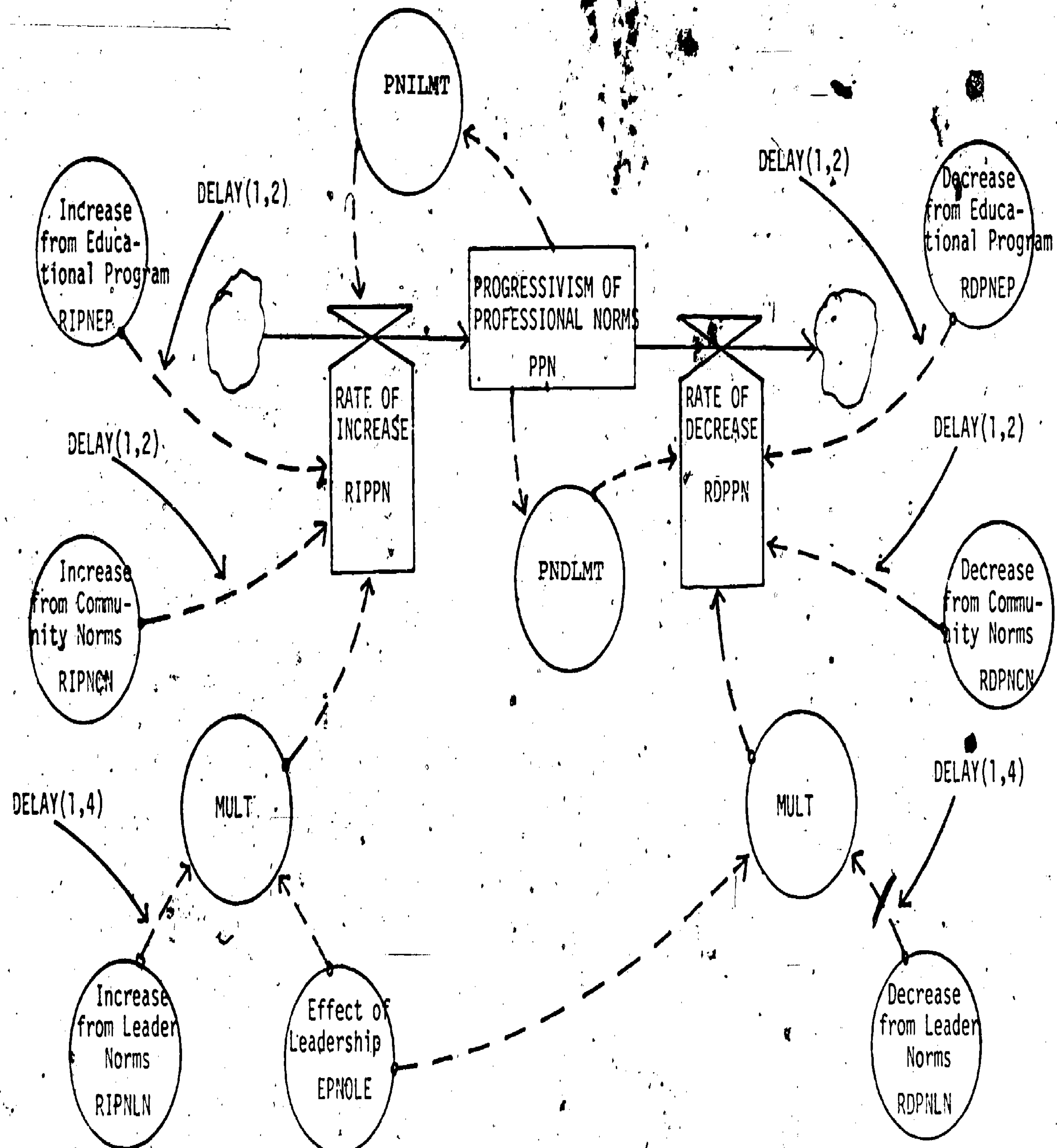
SUPPORT FOR INNOVATION SECTOR



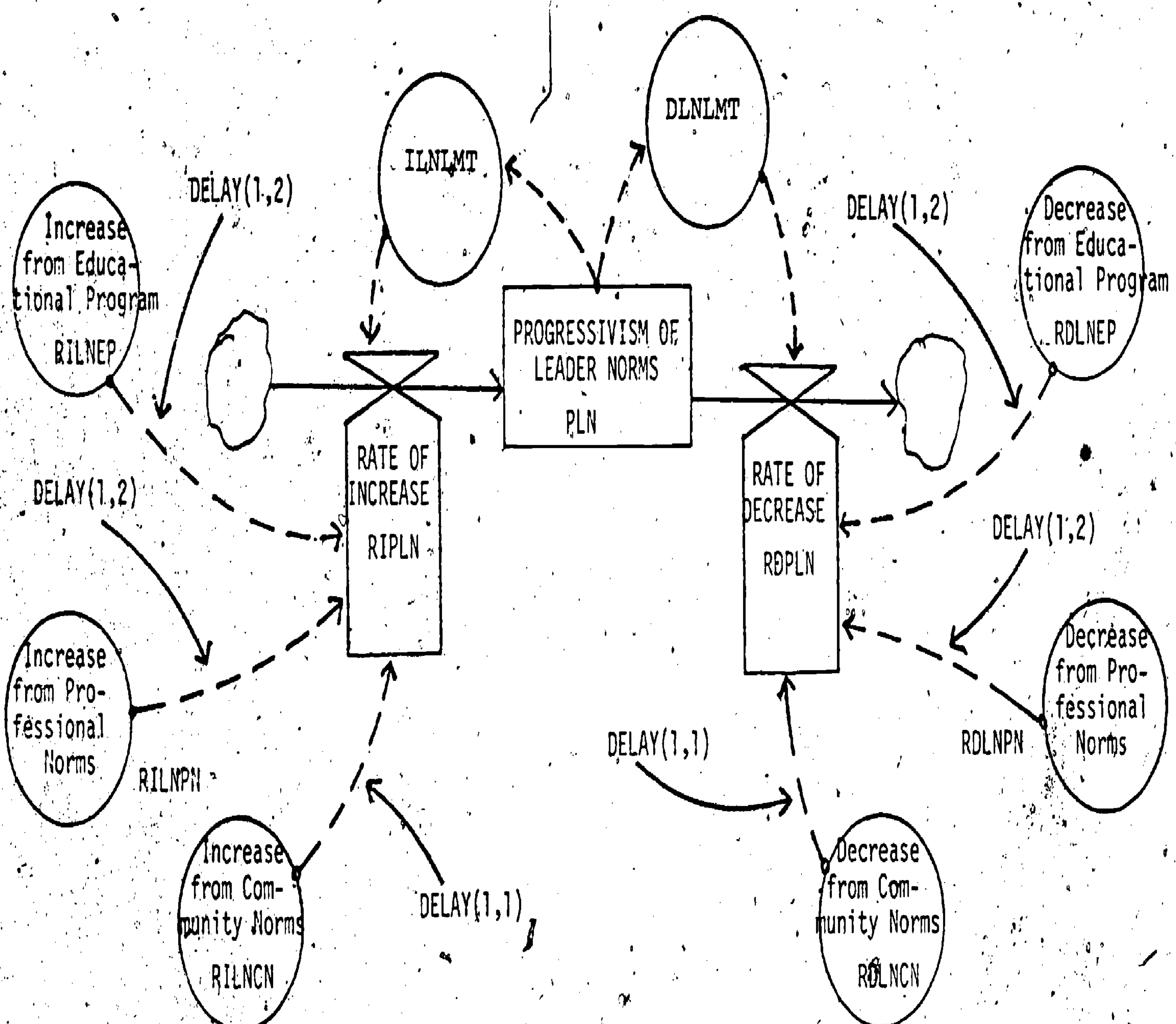
CONFLICT SECTOR



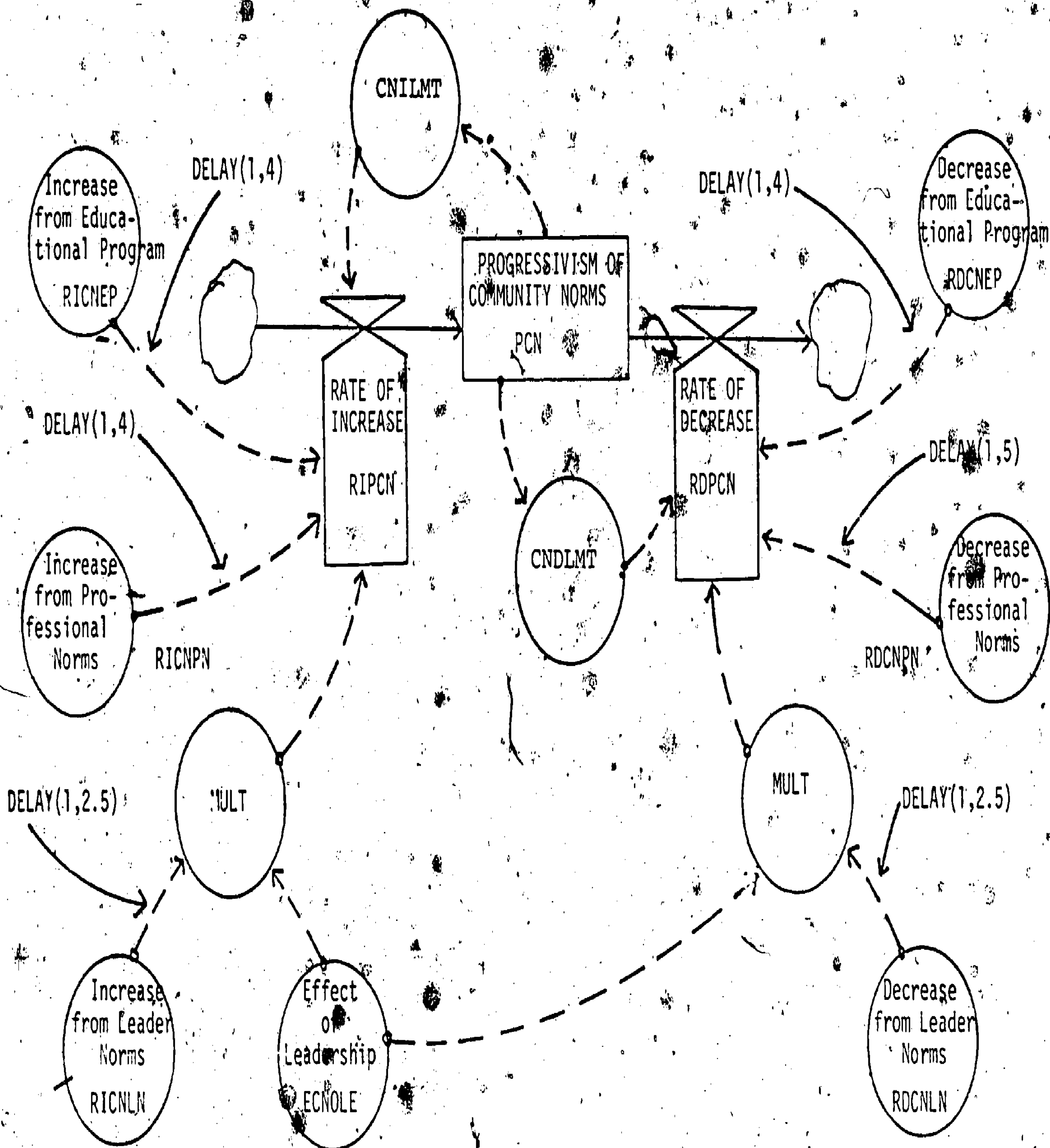
PROFESSIONAL NORMS SECTOR



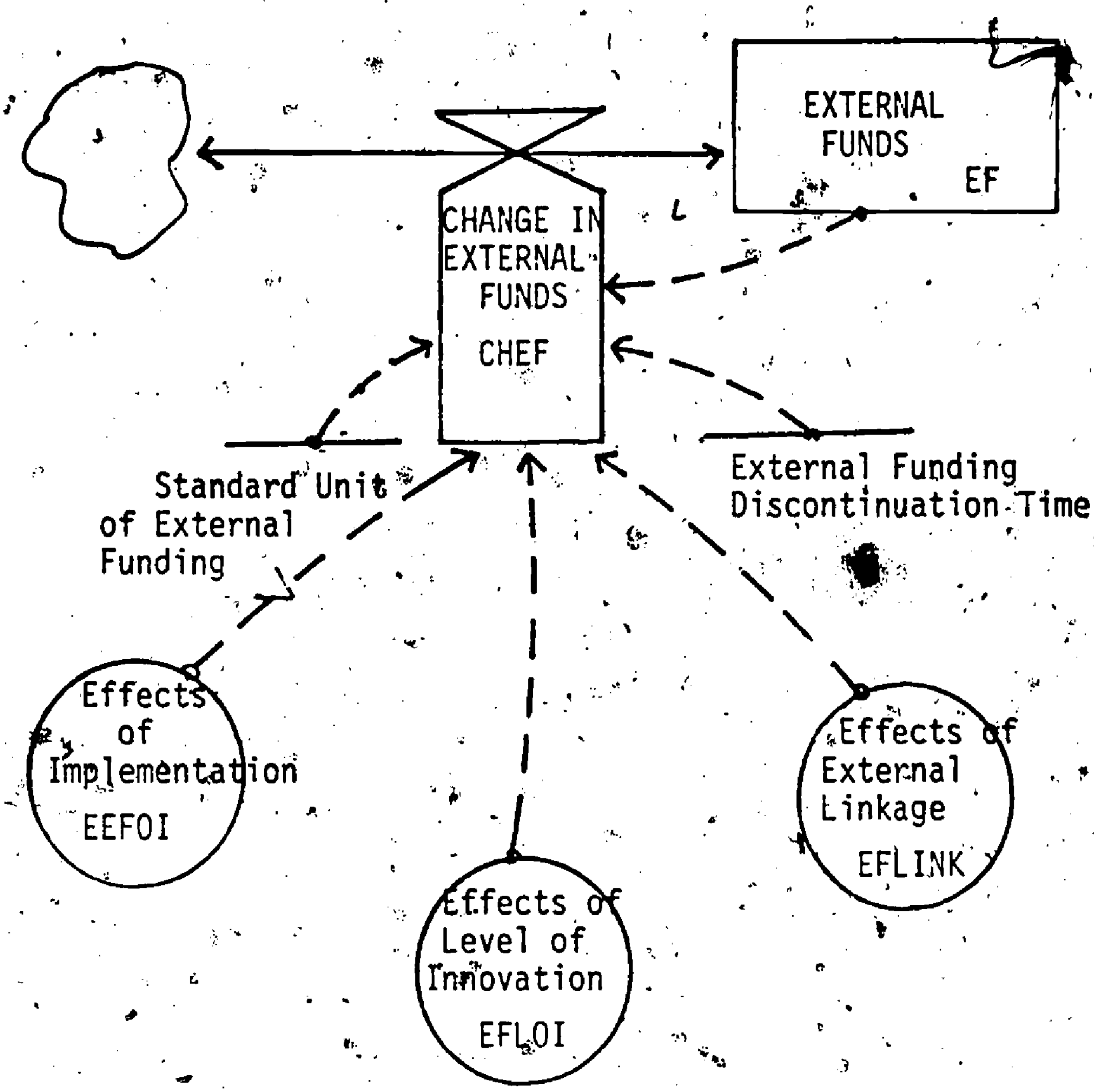
LEADER NORMS SECTOR



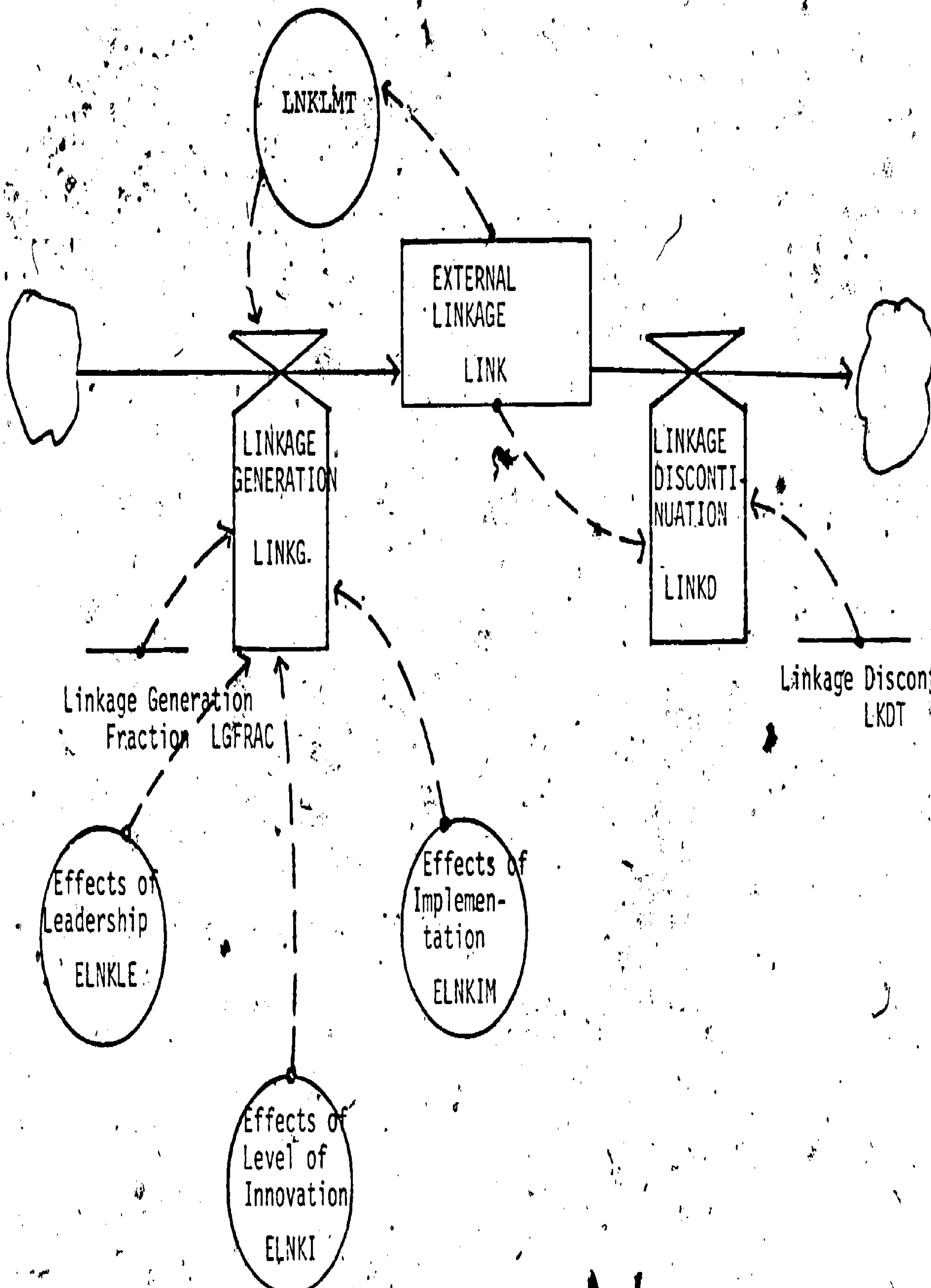
COMMUNITY NORMS SECTOR



EXTERNAL FUNDS SECTOR



EXTERNAL LINKAGE SECTOR



APPENDIX B

List of Abbreviations

List of Model Equations

DYNAMICS OF CHANGE IN SCHOOLS MODEL
LIST OF ABBREVIATIONS

Implementation and Innovation Sector

LOI - LEVEL OF INNOVATION (% OF TOTAL PROGRAM)
IPP - IMPLEMENTATION OF PROGRESSIVE PROGRAMS (% OF PROGRAM/YR.)
STUOI - STANDARD UNIT OF IMPLEMENTATION (% OF PROGRAM/YR.)
EOICW - EFFECT ON IMPLEMENTATION OF COMMUNITY WEALTH (DIMENSIONLESS)
EOIOS - EFFECT ON IMPLEMENTATION OF SUPPORT (DIMENSIONLESS)
EOIEF - EFFECT ON IMPLEMENTATION OF EXTERNAL FUNDS (DIMENSIONLESS)
EOIOLE - EFFECT ON IMPLEMENTATION OF LEADERSHIP EFFECTIVENESS (DIMENSIONLESS)
EOIOC - EFFECT ON IMPLEMENTATION OF CONFLICT (DIMENSIONLESS)
EOIOLN - EFFECT ON IMPLEMENTATION OF LEADER NORMS (DIMENSIONLESS)
ILIMIT - LIMIT ON IMPLEMENTATION (DIMENSIONLESS)

DPP - DISCONTINUATION OF PROGRESSIVE PROGRAMS (% OF PROGRAM/YR.)
STUOD - STANDARD UNIT OF DISCONTINUATION (% OF PROGRAM/YR.)
EODOS - EFFECT ON DISCONTINUATION OF SUPPORT (DIMENSIONLESS)
EODOC - EFFECT ON DISCONTINUATION OF CONFLICT (DIMENSIONLESS)
EODOLE - EFFECT ON DISCONTINUATION OF LEADERSHIP EFFECTIVENESS (DIMENSIONLESS)
EODOEF - EFFECT ON DISCONTINUATION OF EXTERNAL FUNDS (DIMENSIONLESS)
EODOLN - EFFECT ON DISCONTINUATION OF LEADER NORMS (DIMENSIONLESS)
DLIMIT - LIMIT ON DISCONTINUATION (DIMENSIONLESS)

Leadership Effectiveness Sector

LE - LEADERSHIP EFFECTIVENESS (E-UNITS)
GLE - GENERATION OF LEADERSHIP EFFECTIVENESS (E-UNITS/YR.)
STULE - STANDARD UNIT OF LEADERSHIP EFFECTIVENESS (E-UNITS/YR.)
ELGCW - EFFECT ON LEADERSHIP GENERATION OF COMMUNITY WEALTH (DIMENSIONLESS)
ELGLNK - EFFECT ON LEADERSHIP GENERATION OF EXTERNAL LINKAGE (DIMENSIONLESS)
ELGEF - EFFECT ON LEADERSHIP GENERATION OF EXTERNAL FUNDS (DIMENSIONLESS)
GLIMIT - LIMIT ON LEADERSHIP GENERATION (DIMENSIONLESS)

LLE - LOSS OF LEADERSHIP EFFECTIVENESS (E-UNITS/YR.)
NLLF - NORMAL LOSS OF LEADERSHIP FRACTION (E-UNITS/YR.)
EOLLOC - EFFECT ON LEADERSHIP LOSS OF CONFLICT (DIMENSIONLESS)
EOLLOL - EFFECT ON LEADERSHIP LOSS OF EXTERNAL LINKAGE (DIMENSIONLESS)
LLIMIT - LIMIT ON LEADERSHIP LOSS

Support for Innovation Sector

SFI - SUPPORT FOR INNOVATION (D-UNITS)
DISPP - DEMANDS IN SUPPORT OF PROGRESSIVE PROGRAMS (D-UNITS/YR.)
SFLN - SUPPORT FROM LEADER NORMS (D-UNITS/YR.)
EOSOL - EFFECT ON SUPPORT OF LEADERSHIP (DIMENSIONLESS)
SFPN - SUPPORT FROM PROFESSIONAL NORMS (D-UNITS/YR.)
SFCN - SUPPORT FROM COMMUNITY NORMS (D-UNITS/YR.)
SLIMIT - LIMIT ON DEMANDS IN SUPPORT OF PROGRESSIVE PROGRAMS (DIMENSIONLESS)

DIOPP - DEMANDS IN OPPOSITION TO PROGRESSIVE PROGRAMS (D-UNITS/YR.)
OFLN - OPPOSITION FROM LEADER NORMS (D-UNITS/YR.)
OFPN - OPPOSITION FROM PROFESSIONAL NORMS (D-UNITS/YR.)
OFCN - OPPOSITION FROM COMMUNITY NORMS (D-UNITS/YR.)
OLIMIT - LIMIT ON OPPOSITION TO PROGRESSIVE PROGRAMS (DIMENSIONLESS)

Conflict Sector

CON - CONFLICT (C-UNITS)
CG - CONFLICT GENERATION (C-UNITS/YR.)
STUOC - STANDARD UNIT OF CONFLICT (C-UNITS/YR.)
CFNEGS - CONFLICT FROM NEGATIVE SUPPORT (DIMENSIONLESS)
CFI - CONFLICT FROM IMPLEMENTATION OF PROGRESSIVE PROGRAMS (DIMENSIONLESS)
CLIMIT - LIMIT ON CONFLICT GENERATION

CR - CONFLICT RESOLUTION (C-UNITS/YR.)
CRAT - CONFLICT RESOLUTION ADJUSTMENT TIME (YEARS)
ECROL - EFFECT ON CONFLICT RESOLUTION OF LEADERSHIP (DIMENSIONLESS)

Professional Norms Sector

PPN - PROGRESSIVISM OF PROFESSIONAL NORMS (% OF TOTAL PROGRAM)
RIPPN - RATE OF INCREASE OF PROFESSIONAL NORMS (% OF PROGRAM/YR.)
RIPNEP - RATE OF INCREASE IN PROFESSIONAL NORMS FROM EDUCATIONAL PROGRAM (% OF PROGRAM/YR.)
RIPNLN - RATE OF INCREASE IN PROFESSIONAL NORMS FROM LEADER NORMS (% OF PROGRAM/YR.)
EPNOLE - EFFECT ON PROFESSIONAL NORMS OF LEADERSHIP EFFECTIVENESS (DIMENSIONLESS
RIPNCN - RATE OF INCREASE IN PROFESSIONAL NORMS FROM COMMUNITY NORMS (% OF PROGRAM/YR.)
PNILMT - LIMIT ON INCREASE IN PROFESSIONAL NORMS (DIMENSIONLESS)

RDPPN - RATE OF DECREASE IN PROFESSIONAL NORMS (% OF PROGRAM/YR.)

RDPNEP - RATE OF DECREASE IN PROFESSIONAL NORMS FROM EDUCATIONAL PROGRAM (% OF PROGRAM/YR.)

RDPNLN - RATE OF DECREASE IN PROFESSIONAL NORMS FROM LEADER NORMS (% OF PROGRAM/YR.)

RDPNCN - RATE OF DECREASE IN PROFESSIONAL NORMS FROM COMMUNITY NORMS (% OF PROGRAM/YR.)

PNDLMT - LIMIT ON DECREASE IN PROFESSIONAL NORMS (DIMENSIONLESS)

Leader Norms Sector

PLN - PROGRESSIVISM OF LEADER NORMS (% OF TOTAL PROGRAM)

RIPLN - RATE OF INCREASE IN LEADER NORMS (% OF PROGRAM/YR.)

RILNEP - RATE OF INCREASE IN LEADER NORMS FROM EDUCATIONAL PROGRAM (% OF PROGRAM/YR.)

RILNPN - RATE OF INCREASE IN LEADER NORMS FROM PROFESSIONAL NORMS (% OF PROGRAM/YR.)

RILNCN - RATE OF INCREASE IN LEADER NORMS FROM COMMUNITY NORMS (% OF PROGRAM/YR.)

ILNLMT - LIMIT ON INCREASE IN LEADER NORMS (DIMENSIONLESS)

RDPLN - RATE OF DECREASE IN LEADER NORMS (% OF PROGRAM/YR.)

RDLNEP - RATE OF DECREASE IN LEADER NORMS FROM EDUCATIONAL PROGRAM (% OF PROGRAM/YR.)

RDLNPN - RATE OF DECREASE IN LEADER NORMS FROM PROFESSIONAL NORMS (% OF PROGRAM/YR.)

RDLNCN - RATE OF DECREASE IN LEADER NORMS FROM COMMUNITY NORMS (% OF PROGRAM/YR.)

DLNLMT - LIMIT ON DECREASE IN LEADER NORMS (DIMENSIONLESS)

Community Norms Sector

PCN - PROGRESSIVISM OF COMMUNITY NORMS (% OF TOTAL PROGRAM)

RIPCN - RATE OF INCREASE IN COMMUNITY NORMS (% OF PROGRAM/YR.)

RICNEP - RATE OF INCREASE IN COMMUNITY NORMS FROM EDUCATIONAL PROGRAM (% OF PROGRAM/YR.)

RICNPN - RATE OF INCREASE IN COMMUNITY NORMS FROM PROFESSIONAL NORMS (% OF PROGRAM/YR.)

RICNLN - RATE OF INCREASE IN COMMUNITY NORMS FROM LEADER NORMS (% OF PROGRAM/YR.)

ECNOLE - EFFECT ON COMMUNITY NORMS OF LEADERSHIP EFFECTIVENESS (DIMENSIONLESS)

CNILMT - LIMIT ON INCREASE IN COMMUNITY NORMS (DIMENSIONLESS)

RDPCN - RATE OF DECREASE IN COMMUNITY NORMS (% OF PROGRAM/YR.)

RDCNEP - RATE OF DECREASE IN COMMUNITY NORMS FROM EDUCATIONAL PROGRAM (% OF PROGRAM/YR.)

RDCNPN - RATE OF DECREASE IN COMMUNITY NORMS FROM PROFESSIONAL NORMS (% OF PROGRAM/YR.)

RDCNLN - RATE OF DECREASE IN COMMUNITY NORMS FROM LEADER NORMS (% OF PROGRAM/YR.)

CNDLMT - LIMIT ON DECREASE IN COMMUNITY NORMS (DIMENSIONLESS)

External Funds Sector

EF - EXTERNAL FUNDS (DOLLARS)

CHEF - CHANGE IN EXTERNAL FUNDS (DOLLARS/YR.)

STUOEF - STANDARD UNIT OF EXTERNAL FUNDING (DOLLARS/YR.)

EEFOI - EFFECT ON EXTERNAL FUNDING OF IMPLEMENTATION (DIMENSIONLESS)

EFLOI - EFFECT ON EXTERNAL FUNDING OF LEVEL OF INNOVATION (DIMENSIONLESS)

EFLINK - EFFECT ON EXTERNAL FUNDING OF EXTERNAL LINKAGE (DIMENSIONLESS)

EFDT - EXTERNAL FUNDING DISCONTINUATION TIME (YEARS)

External Linkage Sector

LINK - EXTERNAL LINKAGE (L-UNITS)

LINKG - LINKAGE GENERATION (L-UNITS/YR.)

LGFRAC - LINKAGE GENERATION FRACTION (L-UNITS/YR.)

ELNKLE - EFFECT ON LINKAGE OF LEADERSHIP EFFECTIVENESS (DIMENSIONLESS)

ELNKI - EFFECT ON LINKAGE OF LEVEL OF INNOVATION (DIMENSIONLESS)

ELNKIM - EFFECT ON LINKAGE OF IMPLEMENTATION (DIMENSIONLESS)

LNKLMT - LIMIT ON LINKAGE GENERATION

LINKD - LINKAGE DISCONTINUATION (L-UNITS/YR.)

LKDT - LINKAGE DISCONTINUATION TIME

```
/DISPLAY CHANGE22
/JOB NSEGS=8
/INCLUDE DYNAMO
*         DYNAMICS OF CHANGE IN SCHOOLS MODEL --A.K.GAYNOR
*
*
*
MACRO PKNSE(MEAN,SDV,TC)
L PKNSE.K=PKNSE.J+(DT/TC)($6*NOISE()+MEAN-PKNSE.J)
N PKNSE.K=MEAN
N $G=SDV*SQRT(24*TC/DT)
MEND
*         IMPLEMENTATION AND INNOVATION SECTOR
*
L LOI.K=LOI.J+DT*(IPP.JK-DPP.JK)        1.0
N LOI=ILOI
C ILOI=10
*
R IPP.KL=(STUOI*(EOICW.K*EOIQS.K*EOIEF.K*EOIOLE.K*EOIOC.K
X +EOIOLN.K*EOIOLE.K)+PKNSE(0,.2,1)*SW11
X +PULSE(10,20,5)*SW12+STEP(2,1975)*SW13.K
X +RAMP(1,1975)*SW14.K+STEP(-2,100)*SW15
X +RAMP(.04,20)*SW16.K)*IL[illegible]T.K        1.1
C SW11=0
C SW12=0
A SW13.K=CLIP(0,0,TIME.K,1980)
A SW14.K=CLIP(0,0,TIME.K,1980)
C SW15=0
A SW16.K=CLIP(0,0,TIME.K,70)
C STUOI=.2
A EOICW.K=TABHL(TEOICW,CWR.K,.2,3,.4)        1.1.1
T TEOICW=.1,.5,1,1.3,2,2.6,2.8,3
A CWR.K=CW.K/NCW        1.1.2
C NCW=1
A CW.K=CWC        1.1.3
C CWC=1
A EIOS.K=TABHL(TEIOS,SFI.K,-100,100,20)        1.1.4
T TEIOS=0,.1,.2,.5,.85,1,3,5,7,9,10        1.1.4
A EOIOS.K=DELAY1(EIOS.K,3)
A EOIOLE.K=TABHL(TEOIOLE,LER.K,.2,3,.4)        1.1.5
T TEOIOLE=.33,.5,1,1.2,1.5,1.9,2.5,3
A EOIEF.K=TABHL(TEOIEF,EF.K,0,100,10)        1.1.6
T TEOIEF=.5,1,2,3,4,5,[illegible],8,9,10
A EIOC.K=TABHL(TEIOC,CON.K,0,100,10)        1.1.7
T TEIOC=1,1.2,1.1,1,.9,.8,[illegible],.4,.3,.1,0
A EOIOC.K=DELAY1(EIOC.K,2)
A EOIOLN.K=TABHL(TEOIOLN,SDLNEF.K,0,100,10)        1.1.8
T TEOIOLN=0,1,1.5,2,2.3,2.5,2.7,2.8,2.9,2.95,3
A SDLNEF.K=PLN.K-LOI.K        1.1.9
A ILIMIT.K=TABHL(TILIMIT,LOI.K,80,100,4)        1.1.11
T TILIMIT=1,.9,.8,.7,.5,0
```

```
*
R DPP.KL=(STUOD.K*(EODOS.K*EODOC.K*EODOLE.K*EODOEF.K
X +EODOLN.K*EODOLE.K)+PKNSE(0,.2,1)
X *SW21+PULSE(10,20,5)*SW22+STEP(.248,20)*SW23
X +RAMP(2,20)*SW24)*DLIMIT.K      1.2
C SW21=0
C SW22=0
C SW23=0
C SW24=0
A STUOD.K=(STUOI/10)*LOI.K      1.2.1
A EDOS.K=TABHL(TEDOS,SFI.K,-100,60,20)      1.2.2
T TEDOS=10,9,7,5,3,1,.85,.5,.3
A EODOS.K=DELAY1(EDOS.K,2)
A EDOC.K=TABHL(TEDOC,CON.K,0,100,10)
T TEDOC=1,1.25,1.5,2,3,5,10,20,40,80,160
A EODOC.K=DELAY1(EDOC.K,1)
A EODOLE.K=TABHL(TEODOLE,LER.K,-3,3,1)      1.2.3
T TEODOLE=3,2.5,1.5,1.2,1,.5,.33
A EODOEF.K=TABHL(TEODOEF,EF.K,0,100,10)      1.2.4
T TEODOEF=1,1,.98,.95,.9,.84,.77,.72,.68,.66,.65
A EODOLN.K=TABHL(TEODOLN,SDLNEP.K,-100,0,10)      1.2.5
T TEODOLN=3,2.95,2.9,2.8,2.7,2.5,2.3,2,1.5,1,0
A DLIMIT.K=TABHL(TDLIMIT,LOI.K,0,5,1)      1.2.6
T TDLIMIT=0,.5,.7,.8,.9,1
*
*         LEADERSHIP EFFECTIVENESS SECTOR
*
L LE.K=LE.J+DT*(GLE.JK-LLE.JK)      2.0
N LE=ILE
C ILE=10
*
R GLE.KL=(STULE*ELGCW.K*ELGLNK.K*ELGEF.K+PKNSE
X (0,.2,1)*SW31+PULSE(10,20,5)*SW32+STEP(.248,20)
X *SW33+RAMP(.2,1975)*SW34.K)*GLIMIT.K      2.1
C SW31=0
C SW32=0
C SW33=0
A SW34.K=CLIP(0,0,TIME.K,1985)
C STULE=.2
A ELGCW.K=TABHL(TELGCW,CWR.K,.5,3,.5)      2.1.1
T TELGCW=.7,1,1.2,1.5,1.8,2
A ELGLNK.K=TABHL(TELGLNK,LINK.K,0,100,10)      2.1.3
T TELGLNK=.8,1,1.5,2.5,5,5,3,2,1,.8,.6
A ELEF.K=TABHL(TELEF,EF.K,0,100,10)      2.1.3
T TELEF=1,1,1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8,1.9
A ELGEF.K=DELAY1(ELEF.K,3)
A LER.K=LE.K/NLE      2.1.4
C NLE=10
A GLIMIT.K=TABHL(TGLIMIT,LE.K,40,100,20)      2.1.5
T TGLIMIT=1,.8,.4,0
*
R LLE.KL=(NLLF*LE.K*EOLLOC.K*EOLLOL.K+PKNSE
X (0,.2,1)*SW41+PULSE(10,20,5)*SW42+STEP(.248,20)
X *SW43+RAMP(2,20)*SW44)*LLIMIT.K      2.2
C SW41=0
C SW42=0
C SW43=0
C SW44=0
A EOLLOC.K=TABHL(TEOLLOC,CON.K,0,100,10)      2.2.1
T TEOLLOC=1,1,1.1,1.3,1.7,2.5,4.1,7.3,8.9,9.7,10
A EOLLOL.K=TABHL(TEOLLOL,LINK.K,30,100,10)      2.2.2
T TEOLLOL=1,.9,.7,.9,1,1.2,1.5,2
C NLLF=.02
A LLIMIT.K=TABHL(TLLIMIT,LE.K,0,10,1)      2.2.3
T TLLIMIT=0,.1,.2,.3,.4,.5,.6,.7,.8,.9,1
```

```
*       SUPPORT FOR INNOVATION SECTOR
*
L SFI.K=SFI.J+DT*(DISPP.JK-DIOPP.JK-RDRTZ.JK)          3.0
N SFI=ISFI
C ISFI=0
*
R DISPP.KL=(SFLN.K*EOSOL.K+DELAY1(SFPN,1)
X +DELAY1(SFCN.K,2)
X +PKNSE(0,.2,1)*SW51+PULSE(20,20,10)
X *SW52+STEP(50,20)*SW53+RAMP(.1,10)*SW54)*SLIMIT.K          3.1
C SW51=0
C SW52=0
C SW53=0
C SW54=0
A SFLN.K=TABHL(TSFLN,SDLNEP.K,0,20,4)          3.1.1
T TSFLN=0,1,5,6,6.5,7
A SFPN.K=TABHL(TSFPN,SDPNEP.K,0,20,4)          3.1.2
T TSFPN=0,1,5,6,6.5,7
A SFCN.K=TABHL(TSFCN,SDCNEP.K,0,20,4)          3.1.3
T TSFCN=0,1,10,15,20,25
A SDPNEP.K=PPN.K-LOI.K          3.1.5
A SDCNEP.K=PCN.K-LOI.K          3.1.6
A EOSOL.K=TABHL(TEOSOL,LE.K,0,100,20)          3.1.8
T TEOSOL=1,1.2,2,2.4,2.8,3
A SLIMIT.K=TABHL(TSLIMIT,SFI.K,80,100,5)          3.1.9
T TSLIMIT=1,.8,.4,.1,0
*
R DIOPP.KL=(OFLN.K*EOSOL.K+DELAY1(OFPN.K,1)+DELAY1(OFCN.K,
X 2)+PKNSE(0,.2,1)*SW311+PULSE(.248,20,10)*SW312+STEP
X (.248,20)*SW313+RAMP(.0001,20)*SW314)*OLIMIT.K          3.2
A OFLN.K=TABHL(TOFLN,SDLNEP.K,-20,0,4)          3.2.1
T TOFLN=7,6.5,6,5,1,0
A OFPN.K=TABHL(TOFPN,SDPNEP.K,-20,0,4)          3.2.2
T TOFPN=7,6.5,6,5,1,0
A OFCN.K=TABHL(TOFCN,SDCNEP.K,-20,0,4)          3.2.3
T TOFCN=25,20,15,10,1,0
A OLIMIT.K=TABHL(TOLIMIT,SFI.K,-100,-90,1)          3.2.4
T TOLIMIT=0,.1,.2,.3,.4,.5,.6,.7,.8,.9,1
C SW311=0
C SW312=0
C SW313=0
C SW314=0
*
R RDRTZ.KL=SFI.K/SDAT
C SDAT=2
*
```

```
*          CONFLICT SECTOR
*
L CON.K=CON.J+DT*(CG.JK-CR.JK)          4.0
N CON=ICON
C ICON=0
*
R CG.KL=(STUOC*(CFNEGS.K+CFI.K)+PKNSE(0,.2,1)*SW61
X +PULSE(2,20,10)*SW62+STEP(2,20)*SW63
X +RAMP(2,20)*SW64+STEP(-2,23)*SW65)*CLIMIT.K      4.1
A CFNEGS.K=TABHL(TCFNEGS,SFI.K,-40,0,10)       4.1.1
T TCFNEGS=16,8,4,2,0
A CLIMIT.K=TABHL(TCLIMIT,CON.K,70,100,10)       4.1.2
T TCLIMIT=1,.5,.2,0
C SW61=0
C SW62=0
C SW63=0
C SW64=0
C SW65=0
C STUOC=2
A CFI.K=TABHL(TCFI,CIR.K,1,11,2)        4.1.18
T TCFI=0,1,2,4,8,16
A CIR.K=RIA.K/LTIA.K       4.1.19
A RIA.K=SMOOTH(IPP.JK,1)        4.1.20
N RIA=STUOI
A LTIA.K=SMOOTH(IPP.JK,10)       4.1.21
N LTIA=STUOI
*
R CR.KL=(CON.K/CRAT.K)*DELAY1(ECROL.K,1)+PKNSE(0,.2,1)*SW71
X +PULSE(3100,10,10)*SW72+STEP(.02,20)*SW73
X +RAMP(1,1975)*SW74.K       4.3
C SW71=0
C SW72=0
C SW73=0
A SW74.K=CLIP(0,0,TIME.K,1980)
A ECROL.K=TABHL(TECROL,LER.K,0,10,1)        4.2.1
T TECROL=0,1,1.5,2,2.3,2.5,2.6,2.7,2.8,2.9,3
A CRAT.K=TABHL(TCRAT,CON.K,0,100,20)        4.2.2
T TCRAT=5,5,5,4,2,1
```

```
*
*      PROFESSIONAL NORMS SECTOR
*
L PPN.K=PPN.J+DT*(RIPPN.JK-RDPPN.JK)        5.0
N PPN=IPPN
C IPPN=10
*
R RIPPN.KL=(DELAY1(RIPNEP.K,2)+(DELAY1(RIPNLN.K,2)*EPNOLE.K)
X +DELAY1(RIPNCN.K,4)+PKNSE(0,.2,1)*SW81
X +PULSE(20,0,50)*SW82+STEP(.248,20)*SW83
X +RAMP(.2,1975)*SW84.K+STEP(-.248,30)*SW85)*PNILMT.K        5.1
C SW81=0
C SW82=0
C SW83=0
A SW84.K=CLIP(0,0,PPN.K,30)
C SW85=0
A RIPNEP.K=TABHL(TRIPNEP,SDEPPN.K,0,50,10)        5.1.1
T TRIPNEP=0,1,3,2,1,0
A SDEPPN.K=LOI.K-PPN.K        5.1.2
A RIPNLN.K=TABHL(TRIPNLN,SDLNPN.K,0,60,10)        5.1.3
T TRIPNLN=0,.5,1,1.5,2,2.5,3
A EPNOLE.K=TABHL(TEPNOLE,LE.K/NLE,0,10,1)        5.1.4
T TEPNOLE=0,1,1.5,2,2.3,2.5,2.6,2.7,2.8,2.9,3
A SDLNPN.K=PLN.K-PPN.K        5.1.5
A RIPNCN.K=TABHL(TRIPNCN,SDCNPN.K,0,60,10)        5.1.6
T TRIPNCN=0,.25,.5,.75,1,1.25,1.5
A SDCNPN.K=PCN.K-PPN.K        5.1.7
A PNILMT.K=TABHL(TPNILMT,PPN.K,80,100,5)        5.1.8
T TPNILMT=1,.8,.4,.1,0
*
R RDPPN.KL=(DELAY1(RDPNEP.K,2)+DELAY1(RDPNLN.K,2)*EPNOLE.K
X +DELAY1(RDPNCN.K,4)+PKNSE(0,.2,1)*SW411+PULSE(20,20,50)
X *SW412+STEP(.248,20)*SW413+RAMP(.0001,20)*SW414+STEP(-.248
X ,30)*SW415)*PNDLMT.K        5.2
C SW411=0
C SW412=0
C SW413=0
C SW414=0
C SW415=0
A RDPNEP.K=TABHL(TRDPNEP,SDEPPN.K,-50,0,10)        5.2.1
T TRDPNEP=0,1,2,3,1,0
A RDPNLN.K=TABHL(TRDPNLN,SDLNPN.K,-60,0,10)        5.2.2
T TRDPNLN=3,2.5,2,1.5,1,.5,0
A RDPNCN.K=TABHL(TRDPNCN,SDCNPN.K,-60,0,10)        5.2.3
T TRDPNCN=1.5,1.25,1,.75,.5,.25,0
A PNDLMT.K=TABHL(TPNDLMT,PPN.K,0,10,1)        5.2.4
T TPNDLMT=0,.1,.2,.3,.4,.5,.6,.7,.8,.9,1
```

```
*
*       LEADER NORMS SECTOR
*
L PLN.K=PLN.J+DT*(RIPLN.JK-RDPLN.JK)          6.0
N PLN=IPLN
C IPLN=10
*
R RIPLN.KL=(DELAY1(RILNEP.K,2)+DELAY1(RILNPN.K,2)
X +DELAY1(RILNCN.K,1)+PKNSE(0,.2,1)
X *SW91+PULSE(PLN.K,10,50)*SW92+STEP(.248,20)*SW93
X +RAMP(.2,1975)*SW94.K+STEP(-.248,25)*SW95)*ILNLMT.K     6.1
A ILNLMT.K=TABHL(TILNLMT,PLN.K,80,100,5)       6.1.1
T TILNLMT=1,.8,.4,.1,0
C SW91=0
C SW92=0
C SW93=0
A SW94.K=CLIP(0,0,PLN.K,30)
C SW95=0
A RILNEP.K=TABHL(TRILNEP,SDEPLN.K,0,50,10)       6.1.2
T TRILNEP=0,1,3,2,1,0
A SDEPLN.K=LOI.K-PLN.K      6.1.2
A RILNPN.K=TABHL(TRILNPN,SDPNLN.K,0,50,10)       6.1.3
T TRILNPN=0,1,3,2,1,0
A SDPNLN.K=PPN.K-PLN.K      6.1.4
A RILNCN.K=TABHL(TRILNCN,SDCNLN.K,0,100,10)      6.1.5
T TRILNCN=0,3,10,15,20,30,40,60,80,90,100
A SDCNLN.K=PCN.K-PLN.K      6.1.6
*
R RDPLN.KL=(DELAY1(RDLNEP.K,2)+DELAY1(RDLNPN.K,2)
X +DELAY1(RDLNCN.K,1)+PKNSE(0,.2,1)*SW211
X +PULSE(PLN.K,10,50)*SW212+RAMP(.0001,20)
X *SW214+STEP(.248,20)*SW213+STEP(-.248,25)
X *SW215)*DLNLMT.K      6.2
A RDLNEP.K=TABHL(TRDLNEP,SDEPLN.K,-50,0,10)       6.2.1
T TRDLNEP=0,1,2,3,1,0
A RDLNPN.K=TABHL(TRDLNPN,SDPNLN.K,-50,0,10)       6.2.2
T TRDLNPN=0,1,2,3,1,0
A RDLNCN.K=TABHL(TRDLNCN,SDCNLN.K,-100,0,10)       6.2.3
T TRDLNCN=100,90,80,60,40,30,20,15,10,3,0
A DLNLMT.K=TABHL(TDLNLMT,PLN.K,0,10,1)       6.2.4
T TDLNLMT=0,.1,.2,.3,.4,.5,.6,.7,.8,.9,1
C SW211=0
C SW212=0
C SW213=0
C SW214=0
C SW215=0
```

```
*
*        COMMUNITY NORMS SECTOR
*
L PCN.K=PCN.J+DT*(RIPCN.JK-RDPCN.JK)     7.0
N PCN=IPCN
C IPCN=10
*
R RIPCN.KL=(DELAY1(RICNEP.K,4)+DELAY1(RICNPN.K,5)
X +DELAY1(RICNLN.K,2.5)*ECNOLE.K+NNSE(0,.2,1)*SW101
X +PULSE(20,20,10)*SW102+STEP(.248,20)*SW103
X +RAMP(.2,1975)*SW104.K+RAMP(.01,20)*SW105.K)*CNILMT.K      7.1
C SW101=0
C SW102=0
C SW103=0
A SW104.K=CLIP(0,0,PCN.K,30)
A SW105.K=CLIP(0,0,PCN.K,10)
A RICNEP.K=TABHL(TRICNEP,SDEPCN.K,0,50,10)      7.1.1
T TRICNEP=0,.1,.3,.2,.1,0
A SDEPCN.K=LOI.K-PCN.K     7.1.2
A RICNPN.K=TABHL(TRICNPN,SDPNCN.K,0,50,10)      7.1.3
T TRICNPN=0,.05,.15,.1,.05,0
A SDPNCN.K=PPN.K-PCN.K     7.1.4
A RICNLN.K=TABHL(TRICNLN,SDLNCN.K,0,50,10)      7.1.5
T TRICNLN=0,.1,.3,.2,.1,0
A SDLNCN.K=PLN.K-PCN.K     7.1.6
A CNILMT.K=TABHL(TCNILMT,PCN.K,80,100,5)      7.1.7
T TCNILMT=1,.8,.4,.1,0
A ECNOLE.K=TABHL(TECNOLE,LE.K/NLE,0,10,1)      7.1.8
T TECNOLE=0,1,1.25,1.5,1.65,1.75,1.8,1.85,1.9,1.95,2
*
R RDPCN.KL=(DELAY1(RDCNEP.K,4)+DELAY1(RDCNPN.K,5)+DELAY1
X (RDCNLN.K,2.5)*ECNOLE.K+NNSE(0,.2,1)*SW501+PULSE(20,20,
X 50)*SW502+STEP(.2,20)*SW503+RAMP(.01,0)*SW504.K+STEP
X (-.24,30)*SW505)*CNDLMT.K     7.2
C SW501=0
C SW502=0
C SW503=0
A SW504.K=CLIP(0,0,PCN.K,30)
C SW505=0
A RDCNEP.K=TABHL(TRDCNEP,SDEPCN.K,-50,0,10)      7.2.1
T TRDCNEP=0,.1,.2,.3,.1,0
A RDCNPN.K=TABHL(TRDCNPN,SDPNCN.K,-50,0,10)      7.2.2
T TRDCNPN=0,.05,.1,.15,.05,0
A RDCNLN.K=TABHL(TRDCNLN,SDLNCN.K,-50,0,10)      7.2.3
T TRDCNLN=0,.1,.2,.3,.1,0
A CNDLMT.K=TABHL(TCNDLMT,PCN.K,0,10,1)      7.2.4
T TCNDLMT=0,.1,.2,.3,.4,.5,.6,.7,.8,.9,1
*
```

```
*
*       EXTERNAL FUNDS SECTOR
*
L EF.K=EF.J+DT*(CHEF.JK)        8.0
N EF=IEF
C IEF=10
*
R CHEF.KL=STUOEF*(EEFOI.K+EFLOI.K+EFLINK.K)-(EF.K/EFDT).
X +PKNSE(0,.2,1)*SW111+PULSE(20,20,10)
X *SW112+STEP(10,20)*SW113
X +RAMP(5,1975)*SW114.K+STEP(-2,40)*SW115
X +RAMP(-.0001,22)*SW116+RAMP(.0001,27)*SW117
X +STEP(-2,50)*SW118+STEP(-2,60)*SW119+STEP(-2,70)
X *SW120+STEP(-2,80)*SW121       8.1
C SW111=0
C SW112=0
C SW113=0
A SW114.K=CLIP(0,0,TIME.K,1980)
C SW115=0
C SW116=0
C SW117=0
C SW118=0
C SW119=0
C SW120=0
C SW121=0
A EEFOI.K=TABHL(TEEFOI,CIR.K,1,5,1)        8.1.1
T TEEFOI=0,.25,.75,1.5,2
C EFDT=2
A EFLOI.K=TABHL(TEFLOI,LOI.K,0,50,10)        8.1.2
T TEFLOI=0,.25,.35,.5,.75,1
A EFLINK.K=TABHL(TEFLINK,LINK.K,0,100,10)        8.1.3
T TEFLINK=0,.25,.5,.8,1.2,1.7,2.3,3,3.8,4.7,5.7
C STUOEF=10
*
*         LINKAGE SECTOR
*
L LINK.K=LINK.J+DT*(LINKG.JK-LINKD.JK)        9.0
N LINK=ILINK
C ILINK=10
*
R LINKG.KL=(LGFRAC*(ELNKLE.K+ELNKI.K+ELNKIM.K)
X +PKNSE(0,.2,1)*SW601+PULSE(20,20,10)*SW602+
X STEP(20,20)*SW603+RAMP(5,1975)*SW604.K)*LNKLMT.K        9.1
C LGFRAC=2.5
A ELNKLE.K=TABHL(TELNKLE,LE.K,10,60,10)        9.1.1
T TELNKLE=.34,1.15,1.35,1.6,1.9,2
A ELNKI.K=TABHL(TELNKI,LOI.K,10,60,10)        9.1.2
T TELNKI=.33,1.15,1.35,1.6,1.9,2
A ELNKIM.K=TABHL(TELNKIM,CIR.K,1,5,1)        9.1.3
T TELNKIM=.33,.5,1,1.75,3
A LNKLMT.K=TABHL(TLNKLMT,LINK.K,80,100,5)        9.1.4
T TLNKLMT=1,.8,.4,.1,0
C SW601=0
C SW602=0
C SW603=0
A SW604.K=CLIP(0,0,TIME.K,1980)
*
R LINKD.KL=LINK.K/LKDT        9.2
C LKDT=4
*
```

```
401 *        SIMULATION CONTROL CARDS
402 *
403 PRINT LOI,IPP,DPP,LE,SFI,CON,PPN,PLN,PCN,EF,LINK
404 PLOT LOI=X,PPN=P,PLN=L,PCN=C(0,100)/
405 X EF=F(0,100)/LINK=Y(0,100)
406 X LE=E(0,100)/CON=Z(0,100)/SFI=S(-100,100)/
407 SPEC DT=.25,PRTPER=0,PLTPER=1
408 N TIME=TIMEI
409 C TIMEI=1970
410 C LENGTH=2020
*GO
```